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ABSTRACT:

PROBLEM TO BE SOLVED: To prevent the diffusion of solder and barrier metal
and to specifically form the structure of a bump electrode by a method wherein
the first connection layer, formed on the barrier metal layer on a bonding pad,
and the solder bump, which is formed on the second connection layer, are
contained in the semiconductor device.

SOLUTION: A semiconductor chip 1, the bonding pad 7 provided on the
semiconductor chip 1, a barrier metal layer 2 to be formed on the bonding pad

7, and the first connection layer 4, which is brought into the state of
stabilized alloy with the barrier metal layer 2 and solder bump material, are
formed. The semiconductor device is fundamentally composed of the second
connection layer 5, containing high density of metal which is not stably
alloyed with the barrier metal layer 2 among solder bump materials and stably
alloyed with the first connection layer, and the solder bump 3 formed on the
second connection layer. As a result, the lowering of connection strength
caused by the diffusion of metal can be prevented.

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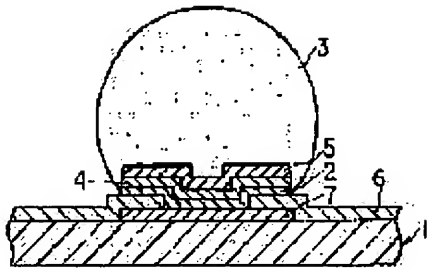
(54) SEMICONDUCTOR AND ITS MANUFACTURE

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent the diffusion of solder and barrier metal and to specifically form the structure of a bump electrode by a method wherein the first connection layer, formed on the barrier metal layer on a bonding pad, and the solder bump, which is formed on the second connection layer, are contained in the semiconductor device.
SOLUTION: A semiconductor chip 1, the bonding pad 7 provided on the semiconductor chip 1, a barrier metal layer 2 to be formed on the bonding pad 7, and the first connection layer 4, which is brought into the state of stabilized alloy with the barrier metal layer 2 and solder bump material, are formed. The semiconductor device is fundamentally composed of the second connection layer 5, containing high density of metal which is not stably alloyed with the barrier metal layer 2 among solder bump materials and stably alloyed with the first connection layer, and the solder bump 3 formed on the second connection layer. As a result, the lowering of connection strength caused by the diffusion of metal can be prevented.



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* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The semiconductor device possessing the bump electrode which has the pewter bump projected and formed on the bonding pad which is characterized by providing the following, and which was prepared on the semiconductor chip and this semiconductor chip, and this bonding pad. The aforementioned bump electrode is the barrier metal layer formed on the bonding pad. The 1st connection layer which it is formed on this barrier metal layer, and carries out stable alloying with pewter bump material. this -- the 2nd connection layer which contains in high concentration the metal which it is formed on the 1st connection layer and does not carry out stable alloying with this barrier metal layer among these pewter bump material rather than a pewter bump this -- the pewter bump formed on the 2nd connection layer
[Claim 2] The bonding pad prepared on the semiconductor chip and this semiconductor chip, And it is the method of manufacturing the semiconductor device possessing the bump electrode which has the pewter bump projected and formed on this bonding pad. The process which forms a barrier metal layer on the aforementioned bonding putt, the process which forms the 1st connection layer which carries out stable alloying with pewter bump material on this barrier metal layer, this -- the process which forms the 2nd connection layer which contains in high concentration the metal which does not carry out stable alloying with this barrier metal layer among these pewter bump material rather than a pewter bump on the 1st connection layer -- and -- this -- the manufacture method of the semiconductor device characterized by including the process which forms a pewter bump on the 2nd connection layer

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[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the bump electrode formed on the bonding pad of the semiconductor chip which starts a semiconductor device, especially carries out flip chip mounting on a circuit wiring substrate, and its manufacture method.
[0002]
[Description of the Prior Art] In recent years, high integration advances and, as for the semiconductor device, mounting technology is also searched for for densification. A semiconductor device is high-density. Since the U.S. Pat. No. 3401126 official report and the U.S. Pat. No. 3429040 official report were indicated, this flip chip mounting technology is large well-known technology.
[0003] Flip chip mounting is technology which interconnects electrically and mechanically, as are shown in drawing 29 , and the bump electrode which has a salient configuration is formed on the bonding pad of a semiconductor chip and the bonding pad of a semiconductor chip and the electrode pad of a circuit wiring substrate are shown in drawing 30 through this bump electrode.
[0004] In flip chip mounting technology, since the coefficient of thermal expansion of a semiconductor chip generally differs from the coefficient of thermal expansion of a circuit wiring substrate mutually, the heat generated working [a semiconductor chip] transmits to a circuit wiring substrate through a bump electrode, and the variation rate resulting from the difference of a coefficient of thermal expansion occurs in a semiconductor chip and a circuit wiring substrate. The generated variation rate makes the bump electrode which connects a circuit wiring substrate with a semiconductor chip generate stress distortion. The stress distortion by the variation rate resulting from the difference of this coefficient of thermal expansion is generated when the heated semiconductor device cools.
[0005] Furthermore, when a temperature gradient arises in outside-temperature atmosphere, the same stress distortion as **** occurs in bump electrode section. The stress distortion of bump electrode section makes the bump electrode by which flip chip mounting was carried out destroyed, and reduces a reliability life.
[0006] A reliability life is IBM. It is Nf=Cf 1/3 as indicated by J.Res.Develop. and 13; 251 (1969). Maximum shear-strain gammamax generated into a bump portion from the formula (C; a constant, f; frequency and Tmax; the maximum temperature) of the cycle life expressed with gammamax-2.exp (1428-/Tmax) It is known by making it decrease that a reliability life will improve. Furthermore, the maximum shear strain generated in the bump electrode shown in the formula of a reliability life is expressed with the following formulas.
[0007]
gammamax ={1-/(Dmin/2) 2/beta} (V/pih1+beta)1-/beta-d-deltaT-deltaalpha (distance from the

difference of the diameter of the Dmin; minimum bump, beta; material constant, V; pewter volume, h; pewter height, and a deltaalpha; coefficient of thermal expansion, a deltaT; temperature gradient, and d; chip center to a bump center)
Therefore, in order to raise the reliability of flip chip mounting, make small distance from the central point of (1) semiconductor chip to the central point of a bump electrode. (2) Make small the difference of the coefficient of thermal expansion of a semiconductor chip, and the coefficient of thermal expansion of a circuit wiring substrate. (3) It has been solved by using meanses, such as making into firm structure (5) bump electrode structure and material which carry out resin restoration and strengthen flip chip mounting structure to stress distortion in the crevice between (4) semiconductor chips which raise thermolysis nature so that a temperature gradient may not become large, and a circuit wiring substrate.
[0008] For example, arrangement of a bump electrode is changed and the method of of (1) which makes small distance from the central point of a semiconductor chip to the central point of a bump electrode is indicated in the Japanese-Patent-Application-No. 4-No. 19855 official report. Moreover, the material of a circuit wiring substrate is taken into consideration, and the proposal of (2) which makes a coefficient of thermal expansion similar and in agreement with the coefficient of thermal expansion of a semiconductor chip has become large well-known technology especially in MCM (Multichip Module).
[0009] Furthermore, in JP,58-23462,A, the proposal which prepares a radiation fin in the rear face of a semiconductor chip is performed, and the method of of (3) which makes small the amount of displacement which makes the temperature change of a semiconductor chip small and is generated serves as well-known technology.
[0010] Furthermore, the method (4) of carrying out resin restoration and carrying out firm [of the mounting structure] to the crevice between a semiconductor chip and a circuit wiring substrate is proposed by JP,61-194732,A, JP,62-252946,A, JP,61-13337,A, JP,4-219944,A, etc.
[0011] Furthermore, the method (5) of strengthening a bump electrode and material to stress distortion is indicated by U.S. JP,3401126,B, JP,60-38839,A, and JP,59-5637,A. The method of controlling this bump electrode structure is using bump structure as the ****** type by JP,62-117346,A and JP,59-218744,A, for example by constituting the composition of a bump electrode from a two-layer combination of a high-melting point and the low melting point, and carrying out a reflow, although the proposal of the former many is performed.
[0012] Moreover, since the stress which joins a bump electrode depends also to the constant of material so that clearly from the formula of the shear strain mentioned above, the proposal which pewter material is limited [proposal] to optimum within the limits, and raises reliability is performed. About pewter material, it is Proc.26th. The effective report is performed for the Pb-5%Sn system alloy to reliability as indicated by ECC, 67, and (1976). Furthermore, in JP,61-65442,A and JP,61-80828,A, stress relaxation is performed by the method adapted to the actual condition by making the content of Sn 65 - 80%, or 50% -- reliability improves.
[0013] However, when using a pewter as a bump electrode material, in order to prevent diffusion with the aluminum and the pewter which are bonding pad material, it is necessary to form the barrier metal which prevents pewter diffusion.
[0014] Especially JP,59-121955,A proposes the solution of the ablation problem to the residual stress in a barrier metal part, and is indicating the method of easing the tensile stress which is inherent in a barrier metal using the titanium layer in which oxygen was distributed by the barrier metal. Although the barrier metal structure using titanium as an adhesion metal is fundamentally inherent in tensile stress, it has proposed it being adapted for a barrier metal in this oxygen-content powder titanium film, and decreasing the poor ablation resulting from tensile stress here by having discovered that the titanium film which distributed oxygen was inherent in compressive stress.

[0015] Furthermore, JP,56-121955,A and U.S. JP,5137845,B make the barrier metal edge which consists of Cr/Cu/Au the structure of having an inclination, and make the stress concentrated on a barrier metal edge ease. Drawing 29 is drawing using the barrier metal which has an inclination at the edge, and with such composition, since the stress to generate can be eased toward the upper part one by one even if stress distortion concentrates on a barrier metal, the reliability over a barrier metal part improves.
[0016] Especially the problem about ablation of the above barrier metals poses an important problem, if bump size turns minutely like recent years.
[0017] A U.S. Pat. No. 4360142 official report and U.S. JP,4290079,B are raising the reliability of the barrier metal which ablation had produced conventionally by making a barrier metal into Cr/Cr-Cu/Cu/Au in order to raise the bond strength of a barrier metal. In addition, with this composition, since Au of the best layer is diffused in a pewter at the time of a reflow, finally copper is arranged at the interface which touches a pewter.
[0018] However, by these methods, when an Cu-Sn alloy is formed when there are many amounts of Sn contained in a pewter, adhesion intensity fell and stress joined a bump electrode, ablation arose in the barrier metal part and there was a problem which the defect of flip chip mounting generates.
[0019] the report to which an intermetallic compound generates in the interface which a pewter and copper touch, and adhesion intensity falls is also performed -- having -- **** -- for example, The International Jounal of Microcircuit and Electronic Packaging Vol.16 No.1 First Quater 1993 -- the relation between Cu-Sn diffusion and a bond-strength fall is indicated this paper -- Cu3 Sn and Cu6 Sn5 etc. -- Cuafter being formed in interface of pewter and copper and forming Cu3 Sn especially on copper6 Sn5 The result to which a bond strength falls is indicated by by growing up. An Cu-Sn state diagram is shown in drawing 31 .
[0020] Then, in JP,3-18497,A, in order to suppress alloy growth of a pewter and copper, copper is made to contain in a pewter and the proposal which prevents the alloy generation in a barrier metal part is performed. moreover, the collection of the 1992 electronic-intelligence communication society autumn convention drafts -- in p5-13, the proposal which arranges a copper timber in a pewter is performed so that copper may be spread in a pewter and a bond strength may not fall The proposal which forms a timber into this pewter is proposed also in JP,5-235102,A, a U.S. Pat. No. 3303393 official report, and JP,60-57957,A.
[0021] However, also in these methods, diffusion advance of copper and tin is not suppressed and the problem which a barrier metal diffusion advances and ablation produces in the barrier metal part of a bump electrode remained by the electronic equipment use in a long time.
[0022] The problem about the fall of the adhesion force in the interface of a pewter and copper is nickel3 Sn4, as it generates also in the nickel generally used as a diffusion barrier metal of a pewter and is shown in drawing 32 . There was a problem to which bump electrode destruction arises by generation and reliability falls.
[0023] make it any -- by the method to the former, forming a bump electrode on a semiconductor chip had the problem which reliability cannot necessarily secure fully by alloying of a pewter and a barrier metal, although it was possible It had become an important problem when copper or nickel was especially used for the best layer of a barrier metal.
[0024]
[Problem(s) to be Solved by the Invention] As mentioned above, by high density and the flip chip mounting method which enables high-speed mounting, there was a very important problem on the reliability which the stress distortion resulting from the difference of the coefficient of thermal expansion of a semiconductor chip and a circuit wiring substrate occurs in bump electrode section, and makes destroy a bump electrode.

[0025] For this reason, as a method of decreasing stress distortion, shorten distance from the central point of (1) semiconductor chip to the central point of a bump electrode. (2) Make small the difference of the coefficient of thermal expansion of a semiconductor chip, and the coefficient of thermal expansion of a circuit wiring substrate. (3) Carry out resin restoration in the crevice between (4) semiconductor chips which raise thermolysis nature so that a temperature gradient may not become large, and a circuit wiring substrate, and strengthen flip chip structure. (5) Methods, such as making bump electrode structure into firm structure to stress distortion, were proposed, and the effect has been demonstrated to some extent.

[0026] Many especially proposals that strengthen bump electrode structure to stress distortion are performed, the laminating of the pewter material of a high-melting point and the low melting point is carried out for bump electrode structure, it is made a ****** type or the proposal which controls the amount of Sn in pewter material to fixed range composition is performed.

[0027] Moreover, on the other hand, in order to prevent diffusion with the pewter of bump material, and the aluminum of bonding pad material and to raise barrier metal adhesion, the proposal which raises reliability is performed by specification-izing barrier metal structure to form and its material.

[0028] Although the method of raising adhesion by making the titanium used as a barrier metal distribute oxygen, the method of forming an inclination in a barrier metal edge and making stress distortion ease one by one, etc. were mentioned to the proposal about this barrier metal, when it turned minutely, it was not necessarily what is solved easily a problem [like recent years] about ablation by the barrier metal part whose bump size is.

[0029] Although the method of forming the alloy layer of the metal which carries out a laminating between each metal layer of the barrier metal which carries out a laminating as a method of preventing ablation by the barrier metal part and raising adhesive strength was proposed, since the adhesion force declined by diffusion with a pewter, the problem by which a bump electrode is destroyed was not solved.

[0030] When copper was used for a barrier metal, it was especially remarkable, and in order that the problem to which adhesive strength falls by this diffusion may make a bump electrode high, when using copper as a timber, it was an important problem. The problem to which adhesive strength falls by diffusion of copper and a pewter was known well, and although the proposal which makes copper contain in a pewter was also performed, since the intermetallic compound of copper and tin was formed when there is much tin volume made to contain in a pewter, the problem to which adhesive strength falls was not solved. In order to have generated when nickel is used as a barrier metal, and for the same problem to raise reliability, there was a problem.

[0031] Furthermore, when making reflow connection of the semiconductor chip with low thermal conductivity which makes the glass substrate the base material, and a big chip size Since a long time is needed until the whole fuses uniformly, melting only of some bump electrodes is carried out, and melting of the good metal of pewter wetting is carried out by the prolonged reflow into a pewter among barrier metals. The bad whole barrier metal of pewter wetting was exposed, and there was also a problem that the adhesion force with a pewter declined.

[0032] Thus, although the proposal which raises adhesive strength about a barrier metal until now was performed, these proposals perform improvement in on the strength of a barrier metal which carries out a laminating, the proposal about the problem to which adhesive strength falls for the intermetallic compound generated by diffusion with a pewter and a barrier metal was not performed, and the problem by which a bump electrode is destroyed by the barrier metal part was not solved.

[0033] this invention carries out offer realization of the reliable semiconductor device by being made in view of the above-mentioned technical problem, preventing diffusion with a pewter and a barrier metal in consideration of the pewter composition which is bump material in the bump electrode of the semiconductor device which carries out flip chip mounting of the semiconductor chip at a circuit

wiring substrate, and specification-izing structure of a bump electrode the optimal beyond the conventional structure.

[0034]

[Means for Solving the Problem] In the semiconductor device possessing the bump electrode which has the pewter bump who this invention projected on the bonding pad prepared [1st] on the semiconductor chip and this semiconductor chip, and this bonding pad, and was formed The barrier metal layer by which the aforementioned bump electrode was formed on the bonding pad, The 1st connection layer which it is formed on this barrier metal layer, and carries out stable alloying with pewter bump material, this -- the 2nd connection layer which contains in high concentration the metal which it is formed on the 1st connection layer and does not carry out stable alloying with this barrier metal layer among these pewter bump material rather than a pewter bump -- this -- the semiconductor device characterized by including the pewter bump formed on the 2nd connection layer is offered

[0035] The bonding pad by which this invention was prepared [2nd] on the semiconductor chip and this semiconductor chip, And it is the method of manufacturing the semiconductor device possessing the bump electrode which has the pewter bump projected and formed on this bonding pad. The process which forms a barrier metal layer on the aforementioned bonding putt, the process which forms the 1st connection layer which carries out stable alloying with pewter bump material on this barrier metal layer, this -- the metal which does not carry out stable alloying with this barrier metal layer among these pewter bump material on the 1st connection layer the process which forms the 2nd connection layer included in high concentration rather than a pewter bump -- and -- this -- the manufacture method of the semiconductor device characterized by including the process which forms a pewter bump on the 2nd connection layer is offered

[0036]

[The gestalt of operation of this invention] The layer of the stable alloy which prevents diffusion advance to the interface of the metal which forms a bump electrode to which a pewter bump touches a barrier metal especially according to this invention, Since formation arrangement of the layer of elements other than the element which forms a stable alloy among the metals which constitute a pewter bump is carried out In order for two kinds of this metal layer formed newly to act as a metal-diffusion stopper film and not to make an intermetallic-compound layer form more than required, it becomes possible to raise connection resilience.

[0037] For this reason, when the semiconductor device is being conventionally used over a long period of time, the bump electrode destruction resulting from ablation of the barrier metal part used as the problem can be prevented, and it becomes possible to raise extremely the reliability of the semiconductor device which carried out flip chip mounting.

[0038] Furthermore, according to this invention, when heating a bump electrode beyond the pewter melting point and making reflow connection, the best layer metal formed as a barrier metal is dissolved in a pewter, and when a ground barrier metal is exposed, it becomes possible to solve the problem of the adhesion force declining.

[0039] Hereafter, with reference to a drawing, this invention is explained concretely.

[0040] Drawing 1 is the cross-section block diagram showing the fundamental structure of the semiconductor device concerning this invention. Drawing 2 is the partial block diagram showing the fundamental structure of the electronic-circuitry equipment which carried out flip chip mounting of the semiconductor device concerning this invention.

[0041] The bonding pad 7 by which this semiconductor device was formed on the semiconductor chip 1 and the semiconductor chip 1 as shown in drawing 1 , The barrier metal layer 2 formed on a bonding pad 7, and the 1st connection layer 4 which carries out stable alloying with the barrier metal layer 2 and pewter bump material, It consists of fundamentally pewter bumps 3 formed on the 2nd connection

layer 5 which contains in high concentration the metal which does not carry out stable alloying with the barrier metal layer 2 among pewter bump material, and carries out stable alloying with the 1st connection layer 4, and the 2nd connection layer 5. The layer which contains at least one sort of metals chosen from Cu, nickel, Au, W, Ag, aluminum, Cr, Ti, etc., for example as a barrier metal layer 2 can be used. Moreover, the layer which contains at least one sort of metals chosen from Pb, Sn, In, Sb, Bi, Ga, and germanium as a pewter bump material can be used.

[0042] This semiconductor device can be applied to electronic-circuitry equipment by connecting with the end-connection child 23 on the circuit board 21 through the pewter bump 3, and carrying out flip chip mounting, as shown in drawing 2 . In addition, the barrier metal layer 2, the 1st connection layer 4, and the 2nd connection layer 5 are collectively expressed as a layered product 61 here.

[0043] The outline cross section of the semiconductor device concerning the gestalt of operation of the 1st of the semiconductor device concerning this invention is shown in drawing 3 .

[0044] In the semiconductor device shown in drawing 3 , the barrier metal layer 2 consists of copper, and consists of a pewter alloy with which the pewter bump's 3 material contains **** at least. Here, they are the Cu3 Sn layer 31 and Cu6 Sn5 as 1st connection layer on the barrier metal layer 2. The metal alloy layer of the two-layer laminated structure formed in order of the layer 32 is formed, the 2nd connection layer 5 by which lead was distributed by high concentration is formed on this, and the pewter bump 3 is formed on it. The Cu3 Sn layer 31 which constitutes the 1st connection layer from a mode of the 1st operation is Cu6 Sn5. As compared with a layer 32, thickness is set up thickly.

[0045] As mentioned above, it sets, when forming copper as the best layer of tin / lead pewter alloy, and a barrier metal as a bump material, and they are a Cu3 Sn alloy and Cu6 Sn5 on copper. By forming an alloy one by one, a stable intermetallic compound is formed and it is Cu6 Sn5 about ****. Since it forms upwards, it becomes possible to prevent diffusion advance with tin / lead pewter, and copper. Moreover, the Cu3 Sn alloy thickness layer formed on copper is Cu6 Sn5. It is desirable to form greatly as compared with a thickness layer, and by making it this composition, an alloy layer serves as the structure where diffusion does not advance more than fixed thickness, and is stabilized further.

[0046] a lead content layer -- a pewter side to Cu6 Sn5 the tin and Cu6 Sn5 to which it be desirable to which to make it the composition which lead concentration increase toward a side, and it exist in a pewter with this composition since diffusion advance of an alloy can be prevent -- as a lead reaction prevention stopper -- more -- effective -- act -- Cu6 Sn5 what generation be suppress for become possible, and connection reliability improve further.

[0047] Furthermore, the outline cross section showing the gestalt of operation of the 2nd of the semiconductor device concerning this invention is shown in drawing 4 . The barrier metal layer 2 consists of an alloy containing nickel, and this semiconductor device consists of a pewter alloy with which the pewter bump 3 contains **** at least, as shown in drawing 4 . here -- the barrier metal layer 2 top -- nickel3 Sn4 from -- the 1st becoming connection layer 41 is formed, the 2nd connection layer 5 which lead becomes from the alloy layer distributed by high concentration is formed on the 1st connection layer 41, and the pewter bump 3 is formed on it

[0048] Here, it is nickel3 Sn4 on nickel. It forms and is nickel3 Sn4 about ****. Since it forms upwards, it has a pewter and the stable structure where diffusion of a barrier metal does not advance.

[0049] At this time, it is a pewter side to nickel3 Sn4 about a lead content layer. Tin and nickel3 Sn4 to which it is desirable to which to consider as the composition which lead concentration increases toward a side, and it exists in a pewter with this composition Diffusion of an alloy is prevented, and it acts as a lead reaction prevention stopper, and is nickel3 Sn4. It becomes possible to suppress reaction generation and connection reliability improves.

[0050] Diffusion of a pewter, copper or nickel, etc., etc. advanced, the cause that the shear strength

was falling to the bottom of hot environments until now came to touch a pewter and the titanium which is not good as for wettability, and ablation had produced it between a pewter and titanium. However, since the alloy layer which may be formed from a pewter, copper, or nickel is beforehand formed as a stopper which prevents diffusion according to this invention, a metal diffusion does not advance more than required and ablation does not arise in a barrier metal part. Therefore, since a shear strength was securable enough, it became possible to raise reliability.

[0051] Below, an example of the method for manufacturing the gestalt of the 1st and operation of the 2nd of this invention is explained.

[0052] The manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt is shown in drawing 5 or drawing 16 .

[0053] As shown in drawing 5 , first, a bonding pad 7 is formed on a semiconductor chip 1, the wafer 1 made from silicon with which the passivation film 6 which consists of a PSG (Lynn silica glass) or SiN (silicon nitride), removing a part of bonding pad 7 is formed is prepared, for example, and the vacuum evaporationo of Cu/Ti is carried out as a barrier metal layer 2 on this silicon wafer 1 on the whole surface. (Cu=1micrometer, Ti=0.1micrometer)
This Cu/Ti film is used as a cathode metal in the case of forming a bump by electroplating. Furthermore, finally this Cu/Ti film serves as the pewter bump's 3 barrier metal layer 2 by **********ing a required portion after formation by electroplating in the pewter bump 3.

[0054] Subsequently, as shown in drawing 6 , on the silicon wafer 1 by which Cu/Ti vacuum evaporationo was carried out, the spin coat of the thick-film resist AZ4903 (Hoechst Japan make) is carried out, and thickness forms the resist layer 51 of 100-micrometer **. 100-micrometer opening to which one side has a size large 5 micrometers at a time by exposure/development in this resist layer 51 rather than the bonding pad which has square of 90-micrometer opening size is formed on a Cu/Ti film.

[0055] Exposure is performed by irradiating sufficient quantity of exposure energy, even if the thickness of a resist is thick, and development is performed by AZ400K developer (Hoechst Japan make). Wall surface angle adjustment of the resist film of the portion which touches a thin film metal is 13th(s). IEMT It is carried out by known method which is indicated by Symp.pp 208 and 1992, and controls by adjusting the distance of exposure energy, a resist side, and a glass mask, and the concentration of a developer.

[0056] With thus, a bigger size than a bonding pad 7 into the portion corresponding to a bonding pad 7 In the silicon wafer 1 by which opening formation is carried out, flood the resist film 51 with the copper-sulfate plating liquid which consists of the following mixed solution, and Cu/Ti is used as cathode with the degree of bath temperature of 25 degrees C. Stirring it gently with current density 1-5 (A/dm2) using the Lynn content (0.03 - 0.08 % of the weight) high grade copper plate as an anode plate, as shown in drawing 7 , 35-micrometer electroplating of the copper 52 is carried out on a Cu/Ti film.

[0057]
Composition of copper-sulfate plating liquid Copper-sulfate 5 hydrate 2 unciae/gallon Sulfuric acid 30 unciae/gallon Hydrochloric acid 10 ppm Thio xanthate-s-propane sulfonic acid (or thio xanthate sulfonic acid) 20 ppm Polyethylene glycol (molecular weight : 400,000) 40 ppm Polyethyleneimine (molecular weight : 600)
A resultant with a benzyl chloride 2 ppm or -- Copper-sulfate 5 hydrate 30 unciae/gallon Sulfuric acid 8 unciae/gallon Hydrochloric acid 30 ppm Dithio carbamate-s-propane sulfonic acid 30 ppm Polypropylene glycol (molecular weight : 700) 10 ppm Polyethyleneimine and allyl bromide Or resultant with a dimethyl sulfate 0.3 It is not necessary to necessarily plate the copper formed at the time of ppm ** to 35-micrometer **, and thickness can be set up arbitrarily if needed. Therefore,

there may not not necessarily be need of carrying out ** attachment of the copper on a Cu/Ti film, and may still be a Cu/Ti film.
[0058] Moreover, the copper in the case of forming on a Cu/Ti film does not necessarily need to be plating, and even if it forms Cu which has predetermined thickness using EB vacuum deposition and the spatter which are well-known technology, it is satisfactory in any way.
[0059] Ablation removal is carried out, as it floods with an acetone and the resist layer 51 which consists of AZ4093 formed as a resist for furthermore carrying out electroplating is shown in drawing 8 . It is also possible to use for example, AZ remover (Hoechst Japan make) as ablation liquid at this time.
[0060] Subsequently, they are 5 micrometers and Cu6 Sn5 about Cu3 Sn to the whole surface to a wafer top. 2 micrometers carries out deposition formation by the spatter one by one, and as shown in drawing 9 , the 1st connection layer 4 is formed. Although the 1st connection layer 4 has a bilayer laminated structure, simple [of it] is carried out and it is shown by the monostromatic. This Cu3 Sn and Cu6 Sn5 It is not limited to a spatter, required equivalent thickness is made to deposit Cu and Sn by the electroplating method, and the deposition method is Cu3 Sn or Cu6 Sn5. You may form with heat treatment so that it may form.
[0061] Subsequently, Cu6 Sn5 The lead content layer 5 is made to deposit upwards. As for this lead content layer 5, it is most desirable to have the composition of having lead composition of a bump metallic material and the amount of said in the interface which approaches a pewter bump in the lead concentration contained in the lead content layer 5 beforehand in consideration of the lead content in the pewter alloy which should be formed on it as a pewter bump and which is made carrying out a Junji Tei fall and touches a pewter alloy.
[0062] Therefore, especially the formation method of a lead content layer is 1 - 4 A/dm2, for example by the electroplating method, although not limited. The method of changing composition one by one with the well-known technology of changing current density in the range is comparatively easy.
[0063] Patterning is carried out with an opening size broader 2 micrometers than the copper salient which formed the resist film of 100-micrometer ** and was furthermore beforehand formed on the lead content layer 5 as it used an electroplating method, and a pewter was shown in drawing 10 using the plating resist AZ4903 using the same method as the above, before carrying out selection formation.
[0064] Subsequently, it changes into the sulfonic-acid pewter plating liquid which indicates a plating bath below, and electroplating is performed like the case of electrolytic copper plating by using for example, the high grade eutectic pewter liquid of the composition corresponding to plating liquid as an anode plate, using Cu/Ti as cathode.
[0065]
Composition of sulfonic-acid pewter plating liquid Tin ion (Sn2+) 12 vol% Lead ion (Pb2+) 30 vol% Aliphatic sulfonic acid 41 vol% Nonion system surfactant 5 vol% Cation system surfactant 5 vol% Isopropyl alcohol 7 Setting vol% current density to 1-4 (A/dm2), and stirring gently with the degree of bath temperature of 25 degrees C pewter composition (Pb/Sn) [almost equal to eutectic composition] Or as shown in drawing 11 , 65 micrometers of pewter alloy layers 3 of the composition which shifted to the Pb or Sn side slightly are deposited on copper 52.
[0066] In this way, plating formation of the pewter alloy layer 3 which is pewter bump material is continuously carried out on a bonding pad 7. Subsequently, as shown in drawing 12 , the resist AZ4903 on a wafer 1 is removed using an acetone.
[0067] Subsequently, on the wafer 1 with which the pewter bump 3 on the Cu/Ti film 2 is formed, the spin coat of the solution which performed same AZ4903 (Hoechst Japan make) or the same viscosity control of OFPR-800 (Tokyo adaptation shrine make) as a plating resist is carried out, and the resist

film 53 is formed on pewter bump 3 front face. Even when plated-metal ** is thick, viscosity control is made into hyperviscosity so that the resist film 53 may be formed to the side of a plating salient electrode.

[0068] The resist film 3 with which it has the resist film 3 on the front face, and it formed the configuration corresponding to the bump metal had 55-micrometer thickness in the portion of the cathode metal which consists of Pb/Cu6 Sn5 / Cu3 Sn/Cu/Ti in which 10 micrometers and the bump metal are not formed on the bump metal.

[0069] Subsequently, after one side with an opening size larger 2 micrometers than pewter bump 100micrometer carries out alignment of the glass mask which has the opening pattern which is 104 micrometers to a required position, it exposes. BEKU [exposure is performed by exposure energy 2000mJ, and / 150 degrees C / a wafer] after exposure on a hot plate.

[0070] Subsequently, it is immersed in a developer and the wafer [BEKU / wafer] is developed.

[0071] By performing the above process, as shown in drawing 13 , the resist film 53 is alternatively formed on the pewter bump 3. The resist film 53 at this time was 75-micrometer width of face in 55 micrometers and the upper part portion in the lower part portion which touches a thin film metal.

[0072] subsequently, the mixed solution of a hydrochloric acid and a nitric acid which consists of an ammonium persulfate, a sulfuric acid, and ethanol after etching the lead content layer 5 by the mixed solution -- Cu3 Sn and Cu6Sn5 from -- etching removal of the becoming layered product 4 is carried out simultaneously Furthermore, etching removal of the required portion of titanium 2 is carried out by the mixed solution which consists of ammonia, ethylenediaminetetraacetic acid, and hydrogen peroxide solution after etching removal in the required portion of copper 52 by the mixed solution which consists of the mixed solution which consists of an ammonium persulfate, a sulfuric acid, and ethanol or a citric acid, hydrogen peroxide solution, and a surfactant, and a semiconductor chip as shown in drawing 14 is obtained. Finally, as shown in drawing 15 , dissolution removal of the covered resist layer 53 for etching is carried out using an acetone. Then, they are Cu3 Sn and Cu6 Sn5 by performing a reflow on the barrier metal which uses copper as the best layer on a semiconductor chip as shown in drawing 16 . And the pewter bump in whom the lead content layer was formed one by one is obtained.

[0073] Moreover, the copper configuration in a bump electrode is not restricted to the configuration shown in drawing 7 . Drawing which expresses other examples of a copper configuration to drawing 17 and drawing 18 is shown. For example, as shown in drawing 17 or drawing 18 , copper thickness can somewhat be enlarged and a bump's height can be specified.

[0074] Below, the manufacturing process of the semiconductor device concerning the gestalt of operation of the 2nd of this invention as shown in drawing 4 is explained.

[0075] On the silicon wafer which has the same composition as the gestalt of the 1st operation, the whole surface vacuum evaporationo of nickel/Ti is carried out as a barrier metal layer 2. This metal composition is not especially limited like the case of Cu/Ti.

[0076] Subsequently, only a required portion carries out selection formation of the plating resist AZ4903 using the same method as the gestalt of the 1st operation, and opening only of the bonding pad portion is carried out.

[0077] In this way, it floods with the nickel-plating liquid with which only a bonding pad portion consists of the following mixed solution the silicon wafer 1 which has the resist by which selection opening was carried out, and electroplating of the nickel of 35-micrometer ** is carried out by using nickel/Ti as cathode with the degree of bath temperature of 50 degrees C, stirring it gently at current density 1-6 (A/dm2) using a high grade nickel board as an anode plate.

[0078]

Composition of nickel-plating liquid Nickel sulfate 240 g/l Nickel chloride 45 g/l Boric acid 30 g/l

Saccharin 19 g/l Formalin 1-2 It ranks second ml/l, the plating resist AZ4903 is removed, and it is nickel3 Sn4. For example, it forms completely by the spatter and the 1st connection layer 41 is formed. Then, the lead content layer 5 is formed like the gestalt of the 1st operation. Composition of this **** has the desirable composition to which concentration decreases one by one toward a pewter bump metal like the gestalt of the 1st operation. A pewter alloy is made to deposit using the still more nearly same method as the gestalt of the 1st operation.

[0079] Moreover, selection formation of the resist layer which consists of AZ4903 which is a resist for **********ing a cathode metal, or OFPR-800 is carried out on a pewter bump using the same method as the gestalt of the 1st operation.

[0080] Subsequently, the lead content layer 5 is **********ed using the same mixed solution as the gestalt of the 1st operation, and it is nickel3 Sn4. And nickel layer is **********ed using the same solution as the gestalt of the 1st operation of Ti, after **********ing with the solution which mixed copper-sulfate 5 hydrate, a methanol, a hydrochloric acid, hydrogen peroxide solution, and pure water.

[0081] Dissolution removal of the etching resist furthermore covered is carried out using an acetone.

[0082] By performing the above process, the bump electrode of composition of being shown in drawing 4 is formed.

[0083] In addition, the configuration of the nickel formed in the interior of the bump electrode at this time is not necessarily limited, and may have structure as shown in drawing 17 and drawing 18 .

[0084] The process which mounts the semiconductor device obtained by doing in this way below in a circuit wiring substrate is explained using drawing 19 or drawing 21 .

[0085] On the other hand, the circuit wiring substrate in which a semiconductor chip is carried is formed using the technology which is a well-known method like U.S. Pat. No. 4811082 or the usual laminating glass epoxy-group board.

[0086] Although not limited especially in the case of this invention, the printed circuit board SLC (Surface Laminar Circuit) substrate of the method to which the build up of an insulating layer and the conductor layer was carried out is used for the quality of the material and structure of a substrate on a glass epoxy-group board as an example here.

[0087] As shown in drawing 19 , puncturing of 110 micrometerphi is prepared for the end-connection child 23 corresponding to the bump electrode of a semiconductor chip in the circuit wiring substrate 21, and Cu is exposed to him. The solder resist 22 is covered in addition to terminal 23 of a substrate.

[0088] Subsequently, alignment of a semiconductor chip and a circuit wiring substrate is performed using the flip chip bonder which has the one-way mirror which is well-known technology, and performs alignment, and as shown in drawing 20 , the end-connection child 23 of the bump electrode 24 and the circuit wiring substrate 21 is contacted electrically and mechanically. At this time, the circuit wiring substrate 21 is held on the stage which has a heating mechanism, and preheating is carried out to 200 degrees C higher than the melting point of Pb/Sn=40/60 in nitrogen-gas-atmosphere mind.

[0089] Temporary connection of a semiconductor chip 1 and the electrode 23 of the circuit wiring substrate 21 is made electrically and mechanically by fusing the pewter which heats the collet 54 holding a semiconductor chip 1 in nitrogen-gas-atmosphere mind in the same temperature of 200 degrees C as the stage in which a substrate 21 is carried, and is prepared in bump 24 front face where a semiconductor chip 1 and the circuit wiring substrate 21 are furthermore contacted.

[0090] Electric and mechanical connections are made to realize by passing the circuit wiring substrate which carried the semiconductor chip all over the reflow furnace finally heated by 250 degrees C which has nitrogen-gas-atmosphere mind. At this time, the position gap of some which the selfer line effect generated and was generated with the surface tension of a pewter at the time of mounting is

corrected, and bonding becomes possible in an exact position.

[0091] By performing the process shown above, the electronic-circuitry equipment which carried out flip chip mounting of a semiconductor device and a semiconductor device as shown in drawing 21 and drawing 2 is realizable.

[0092] In addition, as shown in drawing 22 , it is also possible to close the semiconductor device 1 which carried out flip chip mounting if needed, and the resin which is technology well-known into the crevice portion which the circuit wiring substrate 21 makes.

[0093] The following results were obtained when the reliability of the electronic-circuitry equipment which carried out flip chip mounting of the semiconductor device concerning this invention was evaluated.

[0094] Drawing 23 is the result of evaluating the reliability of the sample which formed the bump electrode of Pb/Sn=40/60 with 256 pieces and 100 micrometers of diameters phi on the 10mmx10mm semiconductor chip, and carried out flip chip mounting on the SLC substrate. It estimated that the case where at least one connection becomes open was poor in 256 pins, and the reliability life (Nf50) was shown in the vertical axis, and the temperature cycle was shown in the horizontal axis. Conditions performed the measurement size by 1000 pieces, and the temperature cycle performed them at (-55 degrees C (30min) - 25 degrees C (5min) - 125 degrees C (30min) - 25 degrees C (5min)).

[0095] When Cu (1 micrometer)/Ti (0.1 micrometers) is formed on a bonding pad, among drawing 231 232 When nickel (1 micrometer)/Ti (0.1 micrometers) is formed, 233 When Pb (5 micrometers)/Cu6 Sn5 / (0.2 micrometers) Cu3 Sn (5 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) is formed, 234 When Pb (5 micrometers) / nickel3 Sn4 / (0.3 micrometers) nickel (1 micrometer) / Ti (0.1 micrometers) is formed, 235 When a resin seal is further performed with the composition of Cu/Ti, 236 When a resin seal is further performed with the composition of nickel/Ti and 237 performs a closure resin to Pb/Cu6 Sn5 / Cu3 Sn/Cu/Ti further, 238 shows respectively the case where a closure resin is further performed to Pb/nickel3 Sn4 / nickel/Ti. In addition, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 was respectively prepared on these layered products.

[0096] Although the defect occurred in 20 cycles and the sample in which Cu (1 micrometer)/Ti (0.1 micrometers) was formed on the bonding pad became a defect 100% in 100 cycles Pb(5 micrometers)/Cu6 Sn5/(0.2 micrometers) (the sample which carried out Cu3 Sn (5 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) formation did not generate the defect up to 1000 cycles, but became poor [100%] in 2000 cycle.) Furthermore, as a result of evaluating the reliability of the sample which closed this sample by the epoxy resin by the well-known method, the defect was not generated up to 3500 cycle, but it turns out that reliability is improved extremely as compared with the case where a defect occurs [the sample which performed the resin seal with the composition of only conventional Cu/Ti] in 3000 cycles.

[0097] Furthermore, although the defect occurred in 50 cycles and the sample in which nickel (1 micrometer)/Ti (0.1 micrometers) was formed on the bonding pad became a defect 100% in 200 cycle, the sample which carried out Pb (5 micrometers) / nickel3 Sn4 / (0.3 micrometers) nickel (1 micrometer) / Ti (0.1 micrometers) formation did not generate the defect up to 1500 cycle, but became poor [100%] in 2500 cycle.

[0098] Furthermore, as a result of evaluating the reliability of the sample which closed this sample by the same epoxy resin as the above, as compared with the case where the sample which did not generate the defect up to 4500 cycle, but carried out the resin seal with the composition of only conventional nickel/Ti carries out poor generating in 3700 cycles, reliability improved extremely.

[0099] In addition, with the composition by this invention, in any case, fracture has arisen in the pewter portion, and the sample which formed only conventional Cu/Ti or conventional nickel/Ti about

the shearing mode when performing an exam was not fractured by the barrier metal part, although fracture had arisen in Cu/Ti or the nickel/Ti portion.

[0100] Drawing 24 is the result of performing a 150-degree C elevated-temperature retention test, and measuring the share intensity of a bump electrode. After solid lines 241, 242, and 243 form Cu (1 micrometer)/Ti (0.1 micrometers), The case where changed Cu on it, changed the thickness to 1 micrometer, 5 micrometers, and 30 micrometers respectively, and it forms is shown. solid lines 244 and 245 They are Cu3 Sn and Cu6 Sn5 on [after forming Cu (1 micrometer)/Ti (0.1 micrometers) respectively] it. And 1000A / 2 micrometers / 5 micrometers, 2 micrometers / 1000A / case where 5 micrometers is made to deposit is respectively shown for Pb. In addition, on these layered products, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 respectively further is prepared.

[0101] When Cu thickness is 1 micrometer, share intensity falls rapidly in 200 hours, and it falls in 400 hours at the time of Cu=5micrometer. Furthermore, although time increases until share intensity falls at the time of 30 micrometers which thickened Cu thickness, a rapid reduction is shown in 800 hours. These shearing modes were what Cu diffused in the pewter and is generated in the interface of a pewter and Ti.

[0102] However, it is Cu3 Sn as shown in 244 of drawing 24 , and 245. Cu6 Sn5 Even if, as for the sample which formed on Cu and formed the high concentration Pb layer on it, a reserve time increases, share intensity does not decrease rapidly. Especially, Cu3 Sn thickness is Cu6 Sn5. When thick as compared with thickness, it turns out that share intensity hardly falls.

[0103] Drawing 25 is the result of carrying out the examination used for drawing 24 , and the same examination about the case where a barrier metal is nickel/Ti. After solid lines 251, 252, and 253 form nickel (1 micrometer)/Ti (0.1 micrometers), The case where changed nickel on it, changed the thickness to 1 micrometer, 5 micrometers, and 30 micrometers respectively, and it forms is shown, and a solid line 254 shows on it the case where nickel3 Sn4 (1 micrometer) / Pb (5 micrometers) formation is carried out, after forming nickel (1 micrometer)/Ti (0.1 micrometers). In addition, on these layered products, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 respectively further is prepared.

[0104] It turns out that share intensity does not fall rapidly, so that nickel thickness becomes thick like the case of drawing 24 . Especially, it is nickel3 Sn4 on nickel/Ti. It forms and is nickel3 Sn4. The share intensity of the sample in which the high concentration Pb layer was formed upwards hardly falls.

[0105] Drawing 26 is Cu3 Sn/Cu6 Sn5 formed on Cu (1 micrometer)/Ti (0.1 micrometers). Or nickel3 Sn4 formed on nickel/Ti It is the result of showing the relation between thickness and share intensity. the inside of drawing, and 261 and 262 -- each Cu3 -- Sn thickness <Cu6 Sn5 Thickness, i.e., Cu3 Sn, 0.1 micrometers Cu6 Sn5 When 2 micrometers is formed, it is Cu3 Sn thickness >Cu6 Sn5. They are 2 micrometers and Cu6 Sn5 in thickness, i.e., Cu3 Sn. The case where 0.1 micrometers is formed is shown and 263 is nickel3 Sn4. The case where 1 micrometer is formed is shown. In addition, on these layered products, 5 micrometers of Pb layers and the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 respectively are prepared further.

[0106] It is Cu3 Sn thickness >Cu6 Sn5 like the result in drawing 24 . The direction in the case of thickness is Cu3 Sn<Cu6 Sn5. As compared with a case, it turns out that intensity is high.

[0107] Furthermore, the Cu3 Sn thickness at this time is the same examination which intensity was high and was separately performed within the limits of 0.05 micrometers - 10 micrometers to Cu6 Sn5. Thickness was understood that share intensity is also high in the range of 0.02 micrometers - 5 micrometers.

[0108] Drawing 27 is drawing having shown the relation of the metaled lead concentration and share

intensity which are formed as 2nd connection layer. Solid lines 271, 272, and 273 show the graphical representation showing the relation between pewter composition Pb:Sn=10:90, Pb:Sn=40:60, the lead concentration at the time of Pb:Sn=90:10, and a bump shear strength respectively. Although lead concentration increases within the limits of the lead concentration > lead concentration under pewter composition according to the pewter composition to form so that it may illustrate, it turns out that lead concentration shows high constant value in pewter composition < lead concentration.

[0109] therefore, lead concentration [in the pewter with which the metal constituted as 2nd connection layer constitutes a bump electrode material when a bump electrode metal is constituted from a tin lead-alloy pewter] < -- it turns out that it is good that it is composition of the lead in the 2nd connection layer

[0110] Moreover, the evaluation result of the reliability is shown about the case where a uniform lead content layer is formed in drawing 28 , and the case where gradual **** to which the lead content was gradually reduced toward the pewter bump layer is formed. It is the result of evaluating the reliability of the sample which formed the layered product of Pb (5 micrometers)/Cu6 Sn5-(0.1 micrometers) Cu3 Sn (2 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) on the bonding pad of a 10mmx10mm semiconductor chip, formed the bump electrode of Pb/Sn=60/40 with 256 pieces and 100 micrometers of diameters phi on it here, and carried out flip chip mounting on the SLC substrate.

[0111] It estimated that the case where at least one connection becomes open was poor in 256 pins, and the reliability life (Nf50) was shown in the vertical axis, and the temperature cycle was shown in the horizontal axis. Conditions performed the measurement size by 1000 pieces, and the temperature cycle performed them at (-55 degrees C (30min) - 25 degrees C (5min) - 125 degrees C (30min) - 25 degrees C (5min)).

[0112] When 281 in drawing forms uniform ****, 282 shows respectively the case where gradual **** is formed.

[0113] It turns out that the direction in the case of the result of drawing 28 to this lead metal layer falling toward a pewter layer more gradually than the uniform layer which has a value with fixed concentration shows high reliability.

[0114] The reliability of the semiconductor device using this invention came from these results enough as compared with the conventional method, and a certain thing was checked.

[0115] In addition, it was also checked that especially reliability of the semiconductor device by this invention improves remarkably when a resin seal is performed.

[0116] The barrier metallic material furthermore used for this invention cannot be limited to Cu and nickel, and can use Au, W, Ag, aluminum, Cr, or Ti. Moreover, as for the pewter bump material to form, for example, not only an Pb-Sn alloy but Sb, Bi, In, Ga, germanium, etc. may be mixed, and the effect does not change at all.

[0117]

[Effect of the Invention] The 1st connection layer which consists of a stable alloy of the metal which forms a bump electrode which prevents diffusion advance between barrier metal and a pewter bump especially according to this invention, Since formation arrangement of the 2nd connection layer which contains in high concentration elements other than the element which forms a stable alloy among the metals which constitute a pewter bump is carried out Two kinds of these metal layers act as a metal-diffusion stopper between barrier metal and a pewter bump, it prevents an intermetallic compound generating more than required, and it becomes possible to prevent the fall of the connection resilience by diffusion. Moreover, when heating a pewter bump beyond the pewter melting point and making reflow connection, the best layer metal formed as a barrier metal can be dissolved in a pewter, a pewter and the ground barrier metal which wettability does not have can contact a pewter, and it can also be prevented the adhesion force's declining.

[0118] Moreover, it is possible to realize easily the reliable semiconductor device with which the bump electrode destruction resulting from exfoliation of the barrier metal portion used as the problem can be prevented when a semiconductor device is used over a long period of time until now according to this invention, and enables it to raise extremely the reliability of the semiconductor device which carried out flip chip mounting, a semiconductor chip is mounted with high density, and share intensity does not fall.

[Translation done.]

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TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the bump electrode formed on the bonding pad of the semiconductor chip which starts a semiconductor device, especially carries out flip chip mounting on a circuit wiring substrate, and its manufacture method.

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PRIOR ART

[Description of the Prior Art] In recent years, high integration advances and, as for the semiconductor device, mounting technology is also searched for for densification. A semiconductor device is high-density. Since the U.S. Pat. No. 3401126 official report and the U.S. Pat. No. 3429040 official report were indicated, this flip chip mounting technology is large well-known technology.
[0003] Flip chip mounting is technology which interconnects electrically and mechanically, as are shown in drawing 29 , and the bump electrode which has a salient configuration is formed on the bonding pad of a semiconductor chip and the bonding pad of a semiconductor chip and the electrode pad of a circuit wiring substrate are shown in drawing 30 through this bump electrode.
[0004] In flip chip mounting technology, since the coefficient of thermal expansion of a semiconductor chip generally differs from the coefficient of thermal expansion of a circuit wiring substrate mutually, the heat generated working [a semiconductor chip] transmits to a circuit wiring substrate through a bump electrode, and the variation rate resulting from the difference of a coefficient of thermal expansion occurs in a semiconductor chip and a circuit wiring substrate. The generated variation rate makes the bump electrode which connects a circuit wiring substrate with a semiconductor chip generate stress distortion. The stress distortion by the variation rate resulting from the difference of this coefficient of thermal expansion is generated when the heated semiconductor device cools.
[0005] Furthermore, when a temperature gradient arises in outside-temperature atmosphere, the same stress distortion as **** occurs in bump electrode section. The stress distortion of bump electrode section makes the bump electrode by which flip chip mounting was carried out destroyed, and reduces a reliability life.
[0006] A reliability life is IBM. It is Nf=Cf 1/3 as indicated by J.Res.Develop. and 13; 251 (1969). Maximum shear-strain gammamax generated into a bump portion from the formula (C; a constant, f; frequency and Tmax; the maximum temperature) of the cycle life expressed with gammamax-2.exp (1428-/Tmax) It is known by making it decrease that a reliability life will improve. Furthermore, the maximum shear strain generated in the bump electrode shown in the formula of a reliability life is expressed with the following formulas.
[0007]
gammamax ={1-/(Dmin/2) 2/beta} (V/pih1+beta)1-/beta-d-deltaT-deltaalpha (distance from the difference of the diameter of the Dmin; minimum bump, beta; material constant, V; pewter volume, h; pewter height, and a deltaalpha; coefficient of thermal expansion, a deltaT; temperature gradient, and d; chip center to a bump center)
Therefore, in order to raise the reliability of flip chip mounting, make small distance from the central point of (1) semiconductor chip to the central point of a bump electrode. (2) Make small the difference of the coefficient of thermal expansion of a semiconductor chip, and the coefficient of thermal

expansion of a circuit wiring substrate. (3) It has been solved by using meanses, such as making into firm structure (5) bump electrode structure and material which carry out resin restoration and strengthen flip chip mounting structure to stress distortion in the crevice between (4) semiconductor chips which raise thermolysis nature so that a temperature gradient may not become large, and a circuit wiring substrate.

[0008] For example, arrangement of a bump electrode is changed and the method of of (1) which makes small distance from the central point of a semiconductor chip to the central point of a bump electrode is indicated in the Japanese-Patent-Application-No. 4-No. 19855 official report. Moreover, the material of a circuit wiring substrate is taken into consideration, and the proposal of (2) which makes a coefficient of thermal expansion similar and in agreement with the coefficient of thermal expansion of a semiconductor chip has become large well-known technology especially in MCM (Multichip Module).

[0009] Furthermore, in JP,58-23462,A, the proposal which prepares a radiation fin in the rear face of a semiconductor chip is performed, and the method of of (3) which makes small the amount of displacement which makes the temperature change of a semiconductor chip small and is generated serves as well-known technology.

[0010] Furthermore, the method (4) of carrying out resin restoration and carrying out firm [of the mounting structure] to the crevice between a semiconductor chip and a circuit wiring substrate is proposed by JP,61-194732,A, JP,62-252946,A, JP,61-13337,A, JP,4-219944,A, etc.

[0011] Furthermore, the method (5) of strengthening a bump electrode and material to stress distortion is indicated by U.S. JP,3401126,B, JP,60-38839,A, and JP,59-5637,A. The method of controlling this bump electrode structure is using bump structure as the ****** type by JP,62-117346,A and JP,59-218744,A, for example by constituting the composition of a bump electrode from a two-layer combination of a high-melting point and the low melting point, and carrying out a reflow, although the proposal of the former many is performed.

[0012] Moreover, since the stress which joins a bump electrode depends also to the constant of material so that clearly from the formula of the shear strain mentioned above, the proposal which pewter material is limited [proposal] to optimum within the limits, and raises reliability is performed. About pewter material, it is Proc.26th. The effective report is performed for the Pb-5%Sn system alloy to reliability as indicated by ECC, 67, and (1976). Furthermore, in JP,61-65442,A and JP,61-80828,A, stress relaxation is performed by the method adapted to the actual condition by making the content of Sn 65 - 80%, or 50% -- reliability improves.

[0013] However, when using a pewter as a bump electrode material, in order to prevent diffusion with the aluminum and the pewter which are bonding pad material, it is necessary to form the barrier metal which prevents pewter diffusion.

[0014] Especially JP,59-121955,A proposes the solution of the ablation problem to the residual stress in a barrier metal part, and is indicating the method of easing the tensile stress which is inherent in a barrier metal using the titanium layer in which oxygen was distributed by the barrier metal. Although the barrier metal structure using titanium as an adhesion metal is fundamentally inherent in tensile stress, it has proposed it being adapted for a barrier metal in this oxygen-content powder titanium film, and decreasing the poor ablation resulting from tensile stress here by having discovered that the titanium film which distributed oxygen was inherent in compressive stress.

[0015] Furthermore, JP,56-121955,A and U.S. JP,5137845,B make the barrier metal edge which consists of Cr/Cu/Au the structure of having an inclination, and make the stress concentrated on a barrier metal edge ease. Drawing 29 is drawing using the barrier metal which has an inclination at the edge, and with such composition, since the stress to generate can be eased toward the upper part one by one even if stress distortion concentrates on a barrier metal, the reliability over a barrier metal part

improves.
[0016] Especially the problem about ablation of the above barrier metals poses an important problem, if bump size turns minutely like recent years.
[0017] A U.S. Pat. No. 4360142 official report and U.S. JP,4290079,B are raising the reliability of the barrier metal which ablation had produced conventionally by making a barrier metal into Cr/Cr-Cu/Cu/Au in order to raise the bond strength of a barrier metal. In addition, with this composition, since Au of the best layer is diffused in a pewter at the time of a reflow, finally copper is arranged at the interface which touches a pewter.
[0018] However, by these methods, when an Cu-Sn alloy is formed when there are many amounts of Sn contained in a pewter, adhesion intensity fell and stress joined a bump electrode, ablation arose in the barrier metal part and there was a problem which the defect of flip chip mounting generates.
[0019] the report to which an intermetallic compound generates in the interface which a pewter and copper touch, and adhesion intensity falls is also performed -- having -- **** -- for example, The International Jounal of Microcircuit and Electronic Packaging Vol.16 No.1 First Quater 1993 -- the relation between Cu-Sn diffusion and a bond-strength fall is indicated this paper -- Cu3 Sn and Cu6 Sn5 etc. -- Cuafter being formed in interface of pewter and copper and forming Cu3 Sn especially on copper6 Sn5 The result to which a bond strength falls is indicated by by growing up. An Cu-Sn state diagram is shown in drawing 31 .
[0020] Then, in JP,3-18497,A, in order to suppress alloy growth of a pewter and copper, copper is made to contain in a pewter and the proposal which prevents the alloy generation in a barrier metal part is performed. moreover, the collection of the 1992 electronic-intelligence communication society autumn convention drafts -- in p5-13, the proposal which arranges a copper timber in a pewter is performed so that copper may be spread in a pewter and a bond strength may not fall The proposal which forms a timber into this pewter is proposed also in JP,5-235102,A, a U.S. Pat. No. 3303393 official report, and JP,60-57957,A.
[0021] However, also in these methods, diffusion advance of copper and tin is not suppressed and the problem which a barrier metal diffusion advances and ablation produces in the barrier metal part of a bump electrode remained by the electronic equipment use in a long time.
[0022] The problem about the fall of the adhesion force in the interface of a pewter and copper is nickel3 Sn4, as it generates also in the nickel generally used as a diffusion barrier metal of a pewter and is shown in drawing 32 . There was a problem to which bump electrode destruction arises by generation and reliability falls.
[0023] make it any -- by the method to the former, forming a bump electrode on a semiconductor chip had the problem which reliability cannot necessarily secure fully by alloying of a pewter and a barrier metal, although it was possible It had become an important problem when copper or nickel was especially used for the best layer of a barrier metal.

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EFFECT OF THE INVENTION

[Effect of the Invention] The metal which forms a bump electrode according to this invention is between barrier metal and a pewter bump especially. Since formation arrangement of the 2nd connection layer which contains in high concentration elements other than the element which forms a stable alloy among the metals which constitute the 1st connection layer and pewter bump which consists of a stable alloy which prevents diffusion advance is carried out Two kinds of these metal layers act as a metal-diffusion stopper between barrier metal and a pewter bump, it prevents an intermetallic compound generating more than required, and it becomes possible to prevent the fall of the connection resilience by diffusion. Moreover, when heating a pewter bump beyond the pewter melting point and making reflow connection, the best layer metal formed as a barrier metal can be dissolved in a pewter, a pewter and the ground barrier metal which wettability does not have can contact a pewter, and it can also be prevented the adhesion force's declining.
[0118] Moreover, it is possible to realize easily the reliable semiconductor device with which the bump electrode destruction resulting from ablation of the barrier metal portion used as the problem can be prevented when a semiconductor device is used over a long period of time until now according to this invention, and enables it to raise extremely the reliability of the semiconductor device which carried out flip chip mounting, a semiconductor chip is mounted with high density, and share intensity does not fall.

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As mentioned above, by high density and the flip chip mounting method which enables high-speed mounting, there was a very important problem on the reliability which the stress distortion resulting from the difference of the coefficient of thermal expansion of a semiconductor chip and a circuit wiring substrate occurs in bump electrode section, and makes destroy a bump electrode.

[0025] For this reason, as a method of decreasing stress distortion, shorten distance from the central point of (1) semiconductor chip to the central point of a bump electrode. (2) Make small the difference of the coefficient of thermal expansion of a semiconductor chip, and the coefficient of thermal expansion of a circuit wiring substrate. (3) Carry out resin restoration in the crevice between (4) semiconductor chips which raise heat dissipation nature so that a temperature gradient may not become large, and a circuit wiring substrate, and strengthen flip chip structure. (5) Methods, such as making bump electrode structure into firm structure to stress distortion, were proposed, and the effect has been demonstrated to some extent.

[0026] Many especially proposals that strengthen bump electrode structure to stress distortion are performed, the laminating of the pewter material of a high-melting point and the low melting point is carried out for bump electrode structure, it is made a ****** type or the proposal which controls the amount of Sn in pewter material to fixed range composition is performed.

[0027] Moreover, on the other hand, in order to prevent diffusion with the pewter of bump material, and the aluminum of bonding pad material and to raise barrier metal adhesion, the proposal which raises reliability is performed by specification-izing barrier metal structure to form and its material.

[0028] Although the method of raising adhesion by making the titanium used as a barrier metal distribute oxygen, the method of forming an inclination in a barrier metal edge and making stress distortion ease one by one, etc. were mentioned to the proposal about this barrier metal, when it turned minutely, it was not necessarily what is solved easily a problem [like recent years] about exfoliation by the barrier metal part whose bump size is.

[0029] Although the method of forming the alloy layer of the metal which carries out a laminating between each metal layer of the barrier metal which carries out a laminating as a method of preventing exfoliation by the barrier metal part and raising adhesive strength was proposed, since the adhesion force declined by diffusion with a pewter, the problem by which a bump electrode is destroyed was not solved.

[0030] When copper was used for a barrier metal, it was especially remarkable, and in order that the problem to which adhesive strength falls by this diffusion may make a bump electrode high, when using copper as a timber, it was an important problem. The problem to which adhesive strength falls by diffusion of copper and a pewter was known well, and although the proposal which makes copper contain in a pewter was also performed, since the intermetallic compound of copper and tin was formed when there is much tin volume made to contain in a pewter, the problem to which adhesive

strength falls was not solved. In order to have generated when nickel is used as a barrier metal, and for the same problem to raise reliability, there was a problem.
[0031] Furthermore, when making reflow connection of the semiconductor chip with low thermal conductivity which makes the glass substrate the base material, and a big chip size Since a long time is needed until the whole fuses uniformly, melting only of some bump electrodes is carried out, and melting of the good metal of pewter wetting is carried out by the prolonged reflow into a pewter among barrier metals. The bad whole barrier metal of pewter wetting was exposed, and there was also a problem that the adhesion force with a pewter declined.
[0032] Thus, although the proposal which raises adhesive strength about a barrier metal until now was performed, these proposals perform improvement in on the strength of a barrier metal which carries out a laminating, the proposal about the problem to which adhesive strength falls for the intermetallic compound generated by diffusion with a pewter and a barrier metal was not performed, and the problem by which a bump electrode is destroyed by the barrier metal part was not solved.
[0033] this invention carries out offer realization of the reliable semiconductor device by being made in view of the above-mentioned technical problem, preventing diffusion with a pewter and a barrier metal in consideration of the pewter composition which is bump material in the bump electrode of the semiconductor device which carries out flip chip mounting of the semiconductor chip at a circuit wiring substrate, and specification-izing structure of a bump electrode the optimal beyond the conventional structure.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] In the semiconductor device possessing the bump electrode which has the pewter bump who this invention projected on the bonding pad prepared [1st] on the semiconductor chip and this semiconductor chip, and this bonding pad, and was formed The barrier metal layer by which the aforementioned bump electrode was formed on the bonding pad, The 1st connection layer which it is formed on this barrier metal layer, and carries out stable alloying with pewter bump material, this -- the 2nd connection layer which contains in high concentration the metal which it is formed on the 1st connection layer and does not carry out stable alloying with this barrier metal layer among these pewter bump material rather than a pewter bump -- this -- the semiconductor device characterized by including the pewter bump formed on the 2nd connection layer is offered
[0035] The bonding pad by which this invention was prepared [2nd] on the semiconductor chip and this semiconductor chip, And it is the method of manufacturing the semiconductor device possessing the bump electrode which has the pewter bump projected and formed on this bonding pad. The process which forms a barrier metal layer on the aforementioned bonding putt, the process which forms the 1st connection layer which carries out stable alloying with pewter bump material on this barrier metal layer, this -- the metal which does not carry out stable alloying with this barrier metal layer among these pewter bump material on the 1st connection layer the process which forms the 2nd connection layer included in high concentration rather than a pewter bump -- and -- this -- the manufacture method of the semiconductor device characterized by including the process which forms a pewter bump on the 2nd connection layer is offered
[0036]
[The form of operation of this invention] The layer of the stable alloy which prevents diffusion advance to the interface of the metal which forms a bump electrode to which a pewter bump touches a barrier metal especially according to this invention, Since formation arrangement of the layer of elements other than the element which forms a stable alloy among the metals which constitute a pewter bump is carried out In order for two kinds of this metal layer formed newly to act as a metal-diffusion stopper film and not to make an intermetallic-compound layer form more than required, it becomes possible to raise connection resilience.
[0037] For this reason, when the semiconductor device is being conventionally used over a long period of time, the bump electrode destruction resulting from exfoliation of the barrier metal part used as the problem can be prevented, and it becomes possible to raise extremely the reliability of the semiconductor device which carried out flip chip mounting.
[0038] Furthermore, according to this invention, when heating a bump electrode beyond the pewter melting point and making reflow connection, the best layer metal formed as a barrier metal is dissolved in a pewter, and when a ground barrier metal is exposed, it becomes possible to solve the problem of the adhesion force declining.
[0039] Hereafter, with reference to a drawing, this invention is explained concretely.

[0040] Drawing 1 is the cross-section block diagram showing the fundamental structure of the semiconductor device concerning this invention. Drawing 2 is the partial block diagram showing the fundamental structure of the electronic-circuitry equipment which carried out flip chip mounting of the semiconductor device concerning this invention.
[0041] The bonding pad 7 by which this semiconductor device was formed on the semiconductor chip 1 and the semiconductor chip 1 as shown in drawing 1 , The barrier metal layer 2 formed on a bonding pad 7, and the 1st connection layer 4 which carries out stable alloying with the barrier metal layer 2 and pewter bump material, It consists of fundamentally pewter bumps 3 formed on the 2nd connection layer 5 which contains in high concentration the metal which does not carry out stable alloying with the barrier metal layer 2 among pewter bump material, and carries out stable alloying with the 1st connection layer 4, and the 2nd connection layer 5. The layer which contains at least one sort of metals chosen from Cu, nickel, Au, W, Ag, aluminum, Cr, Ti, etc., for example as a barrier metal layer 2 can be used. Moreover, the layer which contains at least one sort of metals chosen from Pb, Sn, In, Sb, Bi, Ga, and germanium as a pewter bump material can be used.
[0042] This semiconductor device can be applied to electronic-circuitry equipment by connecting with the end-connection child 23 on the circuit board 21 through the pewter bump 3, and carrying out flip chip mounting, as shown in drawing 2 . In addition, the barrier metal layer 2, the 1st connection layer 4, and the 2nd connection layer 5 are collectively expressed as a layered product 61 here.
[0043] The outline cross section of the semiconductor device concerning the gestalt of operation of the 1st of the semiconductor device concerning this invention is shown in drawing 3 .
[0044] In the semiconductor device shown in drawing 3 , the barrier metal layer 2 consists of copper, and consists of a pewter alloy with which the pewter bump's 3 material contains **** at least. Here, they are the Cu3 Sn layer 31 and Cu6 Sn5 as 1st connection layer on the barrier metal layer 2. The metal alloy layer of the two-layer laminated structure formed in order of the layer 32 is formed, the 2nd connection layer 5 by which lead was distributed by high concentration is formed on this, and the pewter bump 3 is formed on it. The Cu3 Sn layer 31 which constitutes the 1st connection layer from a mode of the 1st operation is Cu6 Sn5. As compared with a layer 32, thickness is set up thickly.
[0045] As mentioned above, it sets, when forming copper as the best layer of tin / lead pewter alloy, and a barrier metal as a bump material, and they are a Cu3 Sn alloy and Cu6 Sn5 on copper. By forming an alloy one by one, a stable intermetallic compound is formed and it is Cu6 Sn5 about ****. Since it forms upwards, it becomes possible to prevent diffusion advance with tin / lead pewter, and copper. Moreover, the Cu3 Sn alloy thickness layer formed on copper is Cu6 Sn5. It is desirable to form greatly as compared with a thickness layer, and by making it this composition, an alloy layer serves as the structure where diffusion does not advance more than fixed thickness, and is stabilized further.
[0046] a lead content layer -- a pewter side to Cu6 Sn5 the tin and Cu6 Sn5 to which it be desirable to which to make it the composition which lead concentration increase toward a side, and it exist in a pewter with this composition since diffusion advance of an alloy can be prevent -- as a lead reaction prevention stopper -- more -- effective -- act -- Cu6 Sn5 what generation be suppress for become possible, and connection reliability improve further.
[0047] Furthermore, the outline cross section showing the gestalt of operation of the 2nd of the semiconductor device concerning this invention is shown in drawing 4 . The barrier metal layer 2 consists of an alloy containing nickel, and this semiconductor device consists of a pewter alloy with which the pewter bump 3 contains **** at least, as shown in drawing 4 . here -- the barrier metal layer 2 top -- nickel3 Sn4 from -- the 1st becoming connection layer 41 is formed, the 2nd connection layer 5 which lead becomes from the alloy layer distributed by high concentration is formed on the 1st connection layer 41, and the pewter bump 3 is formed on it

[0048] Here, it is nickel3 Sn4 on nickel. It forms and is nickel3 Sn4 about ****. Since it forms upwards, it has a pewter and the stable structure where diffusion of a barrier metal does not advance.
[0049] At this time, it is a pewter side to nickel3 Sn4 about a lead content layer. Tin and nickel3 Sn4 to which it is desirable to which to consider as the composition which lead concentration increases toward a side, and it exists in a pewter with this composition Diffusion of an alloy is prevented, and it acts as a lead reaction prevention stopper, and is nickel3 Sn4. It becomes possible to suppress reaction generation and connection reliability improves.
[0050] Diffusion of a pewter, copper or nickel, etc.,.etc. advanced, the cause that the shear strength was falling to the bottom of hot environments until now came to touch a pewter and the titanium which is not good as for wettability, and ablation had produced it between a pewter and titanium. However, since the alloy layer which may be formed from a pewter, copper, or nickel is beforehand formed as a stopper which prevents diffusion according to this invention, a metal diffusion does not advance more than required and ablation does not arise in a barrier metal part. Therefore, since a shear strength was securable enough, it became possible to raise reliability.
[0051] Below, an example of the method for manufacturing the gestalt of the 1st and operation of the 2nd of this invention is explained.
[0052] The manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt is shown in drawing 5 or drawing 16 .
[0053] As shown in drawing 5 , first, a bonding pad 7 is formed on a semiconductor chip 1, the wafer 1 made from silicon with which the passivation film 6 which consists of a PSG (Lynn silica glass) or SiN (silicon nitride), removing a part of bonding pad 7 is formed is prepared, for example, and the vacuum evaporationo of Cu/Ti is carried out as a barrier metal layer 2 on this silicon wafer 1 on the whole surface. (Cu=1micrometer, Ti=0.1micrometer)
This Cu/Ti film is used as a cathode metal in the case of forming a bump by electroplating. Furthermore, finally this Cu/Ti film serves as the pewter bump's 3 barrier metal layer 2 by **********ing a required portion after formation by electroplating in the pewter bump 3.
[0054] Subsequently, as shown in drawing 6 , on the silicon wafer 1 by which Cu/Ti vacuum evaporationo was carried out, the spin coat of the thick-film resist AZ4903 (Hoechst Japan make) is carried out, and thickness forms the resist layer 51 of 100-micrometer **. 100-micrometer opening to which one side has a size large 5 micrometers at a time by exposure/development in this resist layer 51 rather than the bonding pad which has square of 90-micrometer opening size is formed on a Cu/Ti film.
[0055] Exposure is performed by irradiating sufficient quantity of exposure energy, even if the thickness of a resist is thick, and development is performed by AZ400K developer (Hoechst Japan make). Wall surface angle adjustment of the resist film of the portion which touches a thin film metal is 13th(s). IEMT It is carried out by known method which is indicated by Symp.pp 208 and 1992, and controls by adjusting the distance of exposure energy, a resist side, and a glass mask, and the concentration of a developer.
[0056] With thus, a bigger size than a bonding pad 7 into the portion corresponding to a bonding pad 7 In the silicon wafer 1 by which opening formation is carried out, flood the resist film 51 with the copper-sulfate plating liquid which consists of the following mixed solution, and Cu/Ti is used as cathode with the degree of bath temperature of 25 degrees C. Stirring it gently with current density 1-5 (A/dm2) using the Lynn content (0.03 - 0.08 % of the weight) high grade copper plate as an anode plate, as shown in drawing 7 , 35-micrometer electroplating of the copper 52 is carried out on a Cu/Ti film.
[0057]
Composition of copper-sulfate plating liquid Copper-sulfate 5 hydrate 2 unciae/gallon Sulfuric acid 30

unciae/gallon Hydrochloric acid 10 ppm Thio xanthate-s-propane sulfonic acid (or thio xanthate sulfonic acid) 20 ppm Polyethylene glycol (molecular weight : 400,000) 40 ppm Polyethyleneimine (molecular weight : 600)
A resultant with a benzyl chloride 2 ppm or -- Copper-sulfate 5 hydrate 30 unciae/gallon Sulfuric acid 8 unciae/gallon Hydrochloric acid 30 ppm Dithio carbamate-s-propane sulfonic acid 30 ppm Polypropylene glycol (molecular weight : 700) 10 ppm Polyethyleneimine and allyl bromide Or resultant with a dimethyl sulfate 0.3 It is not necessary to necessarily plate the copper formed at the time of ppm ** to 35-micrometer **, and thickness can be set up arbitrarily if needed. Therefore, there may not not necessarily be need of carrying out ** attachment of the copper on a Cu/Ti film, and may still be a Cu/Ti film.
[0058] Moreover, the copper in the case of forming on a Cu/Ti film does not necessarily need to be plating, and even if it forms Cu which has predetermined thickness using EB vacuum deposition and the spatter which are well-known technology, it is satisfactory in any way.
[0059] Ablation removal is carried out, as it floods with an acetone and the resist layer 51 which consists of AZ4093 formed as a resist for furthermore carrying out electroplating is shown in drawing 8 . It is also possible to use for example, AZ remover (Hoechst Japan make) as ablation liquid at this time.
[0060] Subsequently, they are 5 micrometers and Cu6 Sn5 about Cu3 Sn to the whole surface to a wafer top. 2 micrometers carries out deposition formation by the spatter one by one, and as shown in drawing 9 , the 1st connection layer 4 is formed. Although the 1st connection layer 4 has a bilayer laminated structure, simple [of it] is carried out and it is shown by the monostromatic. This Cu3 Sn and Cu6 Sn5 It is not limited to a spatter, required equivalent thickness is made to deposit Cu and Sn by the electroplating method, and the deposition method is Cu3 Sn or Cu6 Sn5. You may form with heat treatment so that it may form.
[0061] Subsequently, Cu6 Sn5 The lead content layer 5 is made to deposit upwards. As for this lead content layer 5, it is most desirable to have the composition of having lead composition of a bump metallic material and the amount of said in the interface which approaches a pewter bump in the lead concentration contained in the lead content layer 5 beforehand in consideration of the lead content in the pewter alloy which should be formed on it as a pewter bump and which is made carrying out a Junji Tei fall and touches a pewter alloy.
[0062] Therefore, especially the formation method of a lead content layer is 1 - 4 A/dm2, for example by the electroplating method, although not limited. The method of changing composition one by one with the well-known technology of changing current density in the range is comparatively easy.
[0063] Patterning is carried out with an opening size broader 2 micrometers than the copper salient which formed the resist film of 100-micrometer ** and was furthermore beforehand formed on the lead content layer 5 as it used an electroplating method, and a pewter was shown in drawing 10 using the plating resist AZ4903 using the same method as the above, before carrying out selection formation.
[0064] Subsequently, it changes into the sulfonic-acid pewter plating liquid which indicates a plating bath below, and electroplating is performed like the case of electrolytic copper plating by using for example, the high grade eutectic pewter liquid of the composition corresponding to plating liquid as an anode plate, using Cu/Ti as cathode.
[0065]
Composition of sulfonic-acid pewter plating liquid Tin ion (Sn2+) 12 vol% Lead ion (Pb2+) 30 vol% Aliphatic sulfonic acid 41 vol% Nonion system surfactant 5 vol% Cation system surfactant 5 vol% Isopropyl alcohol 7 Setting vol% current density to 1-4 (A/dm2), and stirring gently with the degree of bath temperature of 25 degrees C pewter composition (Pb/Sn) [almost equal to eutectic

composition] Or as shown in drawing 11 , 65 micrometers of pewter alloy layers 3 of the composition which shifted to the Pb or Sn side slightly are deposited on copper 52.
[0066] In this way, plating formation of the pewter alloy layer 3 which is pewter bump material is continuously carried out on a bonding pad 7. Subsequently, as shown in drawing 12 , the resist AZ4903 on a wafer 1 is removed using an acetone.
[0067] Subsequently, on the wafer 1 with which the pewter bump 3 on the Cu/Ti film 2 is formed, the spin coat of the solution which performed same AZ4903 (Hoechst Japan make) or the same viscosity control of OFPR-800 (Tokyo adaptation shrine make) as a plating resist is carried out, and the resist film 53 is formed on pewter bump 3 front face. Even when plated-metal ** is thick, viscosity control is made into hyperviscosity so that the resist film 53 may be formed to the side of a plating salient electrode.
[0068] The resist film 3 with which it has the resist film 3 on the front face, and it formed the configuration corresponding to the bump metal had 55-micrometer thickness in the portion of the cathode metal which consists of Pb/Cu6 Sn5 / Cu3 Sn/Cu/Ti in which 10 micrometers and the bump metal are not formed on the bump metal.
[0069] Subsequently, after one side with an opening size larger 2 micrometers than pewter bump 100micrometer carries out alignment of the glass mask which has the opening pattern which is 104 micrometers to a required position, it exposes. BEKU [exposure is performed by exposure energy 2000mJ, and / 150 degrees C / a wafer] after exposure on a hot plate.
[0070] Subsequently, it is immersed in a developer and the wafer [BEKU / wafer] is developed.
[0071] By performing the above process, as shown in drawing 13 , the resist film 53 is alternatively formed on the pewter bump 3. The resist film 53 at this time was 75-micrometer width of face in 55 micrometers and the upper part portion in the lower part portion which touches a thin film metal.
[0072] subsequently, the mixed solution of a hydrochloric acid and a nitric acid which consists of an ammonium persulfate, a sulfuric acid, and ethanol after etching the lead content layer 5 by the mixed solution -- Cu3 Sn and Cu6Sn5 from -- etching removal of the becoming layered product 4 is carried out simultaneously Furthermore, etching removal of the required portion of titanium 2 is carried out by the mixed solution which consists of ammonia, ethylenediaminetetraacetic acid, and hydrogen peroxide solution after etching removal in the required portion of copper 52 by the mixed solution which consists of the mixed solution which consists of an ammonium persulfate, a sulfuric acid, and ethanol or a citric acid, hydrogen peroxide solution, and a surfactant, and a semiconductor chip as shown in drawing 14 is obtained. Finally, as shown in drawing 15 , dissolution removal of the covered resist layer 53 for etching is carried out using an acetone. Then, they are Cu3 Sn and Cu6 Sn5 by performing a reflow on the barrier metal which uses copper as the best layer on a semiconductor chip as shown in drawing 16 . And the pewter bump in whom the lead content layer was formed one by one is obtained.
[0073] Moreover, the copper configuration in a bump electrode is not restricted to the configuration shown in drawing 7 . Drawing which expresses other examples of a copper configuration to drawing 17 and drawing 18 is shown. For example, as shown in drawing 17 or drawing 18 , copper thickness can somewhat be enlarged and a bump's height can be specified.
[0074] Below, the manufacturing process of the semiconductor device concerning the gestalt of operation of the 2nd of this invention as shown in drawing 4 is explained.
[0075] On the silicon wafer which has the same composition as the gestalt of the 1st operation, the whole surface vacuum evaporationo of nickel/Ti is carried out as a barrier metal layer 2. This metal composition is not especially limited like the case of Cu/Ti.
[0076] Subsequently, only a required portion carries out selection formation of the plating resist AZ4903 using the same method as the gestalt of the 1st operation, and opening only of the bonding

pad portion is carried out.
[0077] In this way, it floods with the nickel-plating liquid with which only a bonding pad portion consists of the following mixed solution the silicon wafer 1 which has the resist by which selection opening was carried out, and electroplating of the nickel of 35-micrometer ** is carried out by using nickel/Ti as cathode with the degree of bath temperature of 50 degrees C, stirring it gently at current density 1-6 (A/dm2) using a high grade nickel board as an anode plate.
[0078]
Composition of nickel-plating liquid Nickel sulfate 240 g/l Nickel chloride 45 g/l Boric acid 30 g/l Saccharin 19 g/l Formalin 1-2 It ranks second ml/l, the plating resist AZ4903 is removed, and it is nickel3 Sn4. For example, it forms completely by the spatter and the 1st connection layer 41 is formed. Then, the lead content layer 5 is formed like the gestalt of the 1st operation. Composition of this **** has the desirable composition to which concentration decreases one by one toward a pewter bump metal like the gestalt of the 1st operation. A pewter alloy is made to deposit using the still more nearly same method as the gestalt of the 1st operation.
[0079] Moreover, selection formation of the resist layer which consists of AZ4903 which is a resist for **********ing a cathode metal, or OFPR-800 is carried out on a pewter bump using the same method as the gestalt of the 1st operation.
[0080] Subsequently, the lead content layer 5 is **********ed using the same mixed solution as the gestalt of the 1st operation, and it is nickel3 Sn4. And nickel layer is **********ed using the same solution as the gestalt of the 1st operation of Ti, after **********ing with the solution which mixed copper-sulfate 5 hydrate, a methanol, a hydrochloric acid, hydrogen peroxide solution, and pure water.

[0081] Dissolution removal of the etching resist furthermore covered is carried out using an acetone.
[0082] By performing the above process, the bump electrode of composition of being shown in drawing 4 is formed.
[0083] In addition, the configuration of the nickel formed in the interior of the bump electrode at this time is not necessarily limited, and may have structure as shown in drawing 17 and drawing 18 .
[0084] The process which mounts the semiconductor device obtained by doing in this way below in a circuit wiring substrate is explained using drawing 19 or drawing 21 .
[0085] On the other hand, the circuit wiring substrate in which a semiconductor chip is carried is formed using the technology which is a well-known method like U.S. Pat. No. 4811082 or the usual laminating glass epoxy-group board.
[0086] Although not limited especially in the case of this invention, the printed circuit board SLC (Surface Laminar Circuit) substrate of the method to which the build up of an insulating layer and the conductor layer was carried out is used for the quality of the material and structure of a substrate on a glass epoxy-group board as an example here.
[0087] As shown in drawing 19 , puncturing of 110 micrometerphi is prepared for the end-connection child 23 corresponding to the bump electrode of a semiconductor chip in the circuit wiring substrate 21, and Cu is exposed to him. The solder resist 22 is covered in addition to terminal 23 of a substrate.
[0088] Subsequently, alignment of a semiconductor chip and a circuit wiring substrate is performed using the flip chip bonder which has the one-way mirror which is well-known technology, and performs alignment, and as shown in drawing 20 , the end-connection child 23 of the bump electrode 24 and the circuit wiring substrate 21 is contacted electrically and mechanically. At this time, the circuit wiring substrate 21 is held on the stage which has a heating mechanism, and preheating is carried out to 200 degrees C higher than the melting point of Pb/Sn=40/60 in nitrogen-gas-atmosphere mind.
[0089] Temporary connection of a semiconductor chip 1 and the electrode 23 of the circuit wiring

substrate 21 is made electrically and mechanically by fusing the pewter which heats the collet 54 holding a semiconductor chip 1 in nitrogen-gas-atmosphere mind in the same temperature of 200 degrees C as the stage in which a substrate 21 is carried, and is prepared in bump 24 front face where a semiconductor chip 1 and the circuit wiring substrate 21 are furthermore contacted.

[0090] Electric and mechanical connections are made to realize by passing the circuit wiring substrate which carried the semiconductor chip all over the reflow furnace finally heated by 250 degrees C which has nitrogen-gas-atmosphere mind. At this time, the position gap of some which the selfer line effect generated and was generated with the surface tension of a pewter at the time of mounting is corrected, and bonding becomes possible in an exact position.

[0091] By performing the process shown above, the electronic-circuitry equipment which carried out flip chip mounting of a semiconductor device and a semiconductor device as shown in drawing 21 and drawing 2 is realizable.

[0092] In addition, as shown in drawing 22 , it is also possible to close the semiconductor device 1 which carried out flip chip mounting if needed, and the resin which is technology well-known into the crevice portion which the circuit wiring substrate 21 makes.

[0093] The following results were obtained when the reliability of the electronic-circuitry equipment which carried out flip chip mounting of the semiconductor device concerning this invention was evaluated.

[0094] Drawing 23 is the result of evaluating the reliability of the sample which formed the bump electrode of Pb/Sn=40/60 with 256 pieces and 100 micrometers of diameters phi on the 10mmx10mm semiconductor chip, and carried out flip chip mounting on the SLC substrate. It estimated that the case where at least one connection becomes open was poor in 256 pins, and the reliability life (Nf50) was shown in the vertical axis, and the temperature cycle was shown in the horizontal axis. Conditions performed the measurement size by 1000 pieces, and the temperature cycle performed them at (-55 degrees C (30min) - 25 degrees C (5min) - 125 degrees C (30min) - 25 degrees C (5min)).

[0095] When Cu (1 micrometer)/Ti (0.1 micrometers) is formed on a bonding pad, among drawing 231 232 When nickel (1 micrometer)/Ti (0.1 micrometers) is formed, 233 When Pb (5 micrometers)/Cu6 Sn5 / (0.2 micrometers) Cu3 Sn (5 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) is formed, 234 When Pb (5 micrometers) / nickel3 Sn4 / (0.3 micrometers) nickel (1 micrometer) / Ti (0.1 micrometers) is formed, 235 When a resin seal is further performed with the composition of Cu/Ti, 236 When a resin seal is further performed with the composition of nickel/Ti and 237 performs a closure resin to Pb/Cu6 Sn5 / Cu3 Sn/Cu/Ti further, 238 shows respectively the case where a closure resin is further performed to Pb/nickel3 Sn4 / nickel/Ti. In addition, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 was respectively prepared on these layered products.

[0096] Although the defect occurred in 20 cycles and the sample in which Cu (1 micrometer)/Ti (0.1 micrometers) was formed on the bonding pad became a defect 100% in 100 cycles Pb(5 micrometers)/Cu6 Sn5/(0.2 micrometers) (the sample which carried out Cu3 Sn (5 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) formation did not generate the defect up to 1000 cycles, but became poor [100%] in 2000 cycle.) Furthermore, as a result of evaluating the reliability of the sample which closed this sample by the epoxy resin by the well-known method, the defect was not generated up to 3500 cycle, but it turns out that reliability is improved extremely as compared with the case where a defect occurs [the sample which performed the resin seal with the composition of only conventional Cu/Ti] in 3000 cycles.

[0097] Furthermore, although the defect occurred in 50 cycles and the sample in which nickel (1 micrometer)/Ti (0.1 micrometers) was formed on the bonding pad became a defect 100% in 200 cycle, the sample which carried out Pb (5 micrometers) / nickel3 Sn4 / (0.3 micrometers) nickel (1

micrometer) / Ti (0.1 micrometers) formation did not generate the defect up to 1500 cycle, but became poor [100%] in 2500 cycle.

[0098] Furthermore, as a result of evaluating the reliability of the sample which closed this sample by the same epoxy resin as the above, as compared with the case where the sample which did not generate the defect up to 4500 cycle, but carried out the resin seal with the composition of only conventional nickel/Ti carries out poor generating in 3700 cycles, reliability improved extremely.

[0099] In addition, with the composition by this invention, in any case, fracture has arisen in the pewter portion, and the sample which formed only conventional Cu/Ti or conventional nickel/Ti about the shearing mode when performing an exam was not fractured by the barrier metal part, although fracture had arisen in Cu/Ti or the nickel/Ti portion.

[0100] Drawing 24 is the result of performing a 150-degree C elevated-temperature retention test, and measuring the share intensity of a bump electrode. After solid lines 241, 242, and 243 form Cu (1 micrometer)/Ti (0.1 micrometers), The case where changed Cu on it, changed the thickness to 1 micrometer, 5 micrometers, and 30 micrometers respectively, and it forms is shown. solid lines 244 and 245 They are Cu3 Sn and Cu6 Sn5 on [after forming Cu (1 micrometer)/Ti (0.1 micrometers) respectively] it. And 1000A / 2 micrometers / 5 micrometers, 2 micrometers / 1000A / case where 5 micrometers is made to deposit is respectively shown for Pb. In addition, on these layered products, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 respectively further is prepared.

[0101] When Cu thickness is 1 micrometer, share intensity falls rapidly in 200 hours, and it falls in 400 hours at the time of Cu=5micrometer. Furthermore, although time increases until share intensity falls at the time of 30 micrometers which thickened Cu thickness, a rapid reduction is shown in 800 hours. These shearing modes were what Cu diffused in the pewter and is generated in the interface of a pewter and Ti.

[0102] However, it is Cu3 Sn as shown in 244 of drawing 24 , and 245. Cu6 Sn5 Even if, as for the sample which formed on Cu and formed the high concentration Pb layer on it, a reserve time increases, share intensity does not decrease rapidly. Especially, Cu3 Sn thickness is Cu6 Sn5. When thick as compared with thickness, it turns out that share intensity hardly falls.

[0103] Drawing 25 is the result of carrying out the examination used for drawing 24 , and the same examination about the case where a barrier metal is nickel/Ti. After solid lines 251, 252, and 253 form nickel (1 micrometer)/Ti (0.1 micrometers), The case where changed nickel on it, changed the thickness to 1 micrometer, 5 micrometers, and 30 micrometers respectively, and it forms is shown, and a solid line 254 shows on it the case where nickel3 Sn4 (1 micrometer) / Pb (5 micrometers) formation is carried out, after forming nickel (1 micrometer)/Ti (0.1 micrometers). In addition, on these layered products, the pewter bump who consists of an Pb-Sn alloy of the rate of Pb:Sn=40:60 respectively further is prepared.

[0104] It turns out that share intensity does not fall rapidly, so that nickel thickness becomes thick like the case of drawing 24 . Especially, it is nickel3 Sn4 on nickel/Ti. It forms and is nickel3 Sn4. The share intensity of the sample in which the high concentration Pb layer was formed upwards hardly falls.

[0105] Drawing 26 is Cu3 Sn/Cu6 Sn5 formed on Cu (1 micrometer)/Ti (0.1 micrometers). Or nickel3 Sn4 formed on nickel/Ti It is the result of showing the relation between thickness and share intensity. the inside of drawing, and 261 and 262 -- each Cu3 -- Sn thickness <Cu6 Sn5 Thickness, i.e., Cu3 Sn, 0.1 micrometers Cu6 Sn5 When 2 micrometers is formed, it is Cu3 Sn thickness >Cu6 Sn5. They are 2 micrometers and Cu6 Sn5 in thickness, i.e., Cu3 Sn. The case where 0.1 micrometers is formed is shown and 263 is nickel3 Sn4. The case where 1 micrometer is formed is shown. In addition, on these layered products, 5 micrometers of Pb layers and the pewter bump who consists of an Pb-Sn alloy of

the rate of Pb:Sn=40:60 respectively are prepared further.

[0106] It is Cu3 Sn thickness >Cu6 Sn5 like the result in drawing 24 . The direction in the case of thickness is Cu3 Sn<Cu6 Sn5. As compared with a case, it turns out that intensity is high.

[0107] Furthermore, the Cu3 Sn thickness at this time is the same examination which intensity was high and was separately performed within the limits of 0.05 micrometers - 10 micrometers to Cu6 Sn5. Thickness was understood that share intensity is also high in the range of 0.02 micrometers - 5 micrometers.

[0108] Drawing 27 is drawing having shown the relation of the metaled lead concentration and share intensity which are formed as 2nd connection layer. Solid lines 271, 272, and 273 show the graphical representation showing the relation between pewter composition Pb:Sn=10:90, Pb:Sn=40:60, the lead concentration at the time of Pb:Sn=90:10, and a bump shear strength respectively. Although lead concentration increases within the limits of the lead concentration > lead concentration under pewter composition according to the pewter composition to form so that it may illustrate, it turns out that lead concentration shows high constant value in pewter composition < lead concentration.

[0109] therefore, lead concentration [in the pewter with which the metal constituted as 2nd connection layer constitutes a bump electrode material when a bump electrode metal is constituted from a tin lead-alloy pewter] < -- it turns out that it is good that it is composition of the lead in the 2nd connection layer

[0110] Moreover, the evaluation result of the reliability is shown about the case where a uniform lead content layer is formed in drawing 28 , and the case where gradual **** to which the lead content was gradually reduced toward the pewter bump layer is formed. It is the result of evaluating the reliability of the sample which formed the layered product of Pb (5 micrometers)/Cu6 Sn5-(0.1 micrometers) Cu3 Sn (2 micrometers) / Cu (1 micrometer) / Ti (0.1 micrometers) on the bonding pad of a 10mmx10mm semiconductor chip, formed the bump electrode of Pb/Sn=60/40 with 256 pieces and 100 micrometers of diameters phi on it here, and carried out flip chip mounting on the SLC substrate.

[0111] It estimated that the case where at least one connection becomes open was poor in 256 pins, and the reliability life (Nf50) was shown in the vertical axis, and the temperature cycle was shown in the horizontal axis. Conditions performed the measurement size by 1000 pieces, and the temperature cycle performed them at (-55 degrees C (30min) - 25 degrees C (5min) - 125 degrees C (30min) - 25 degrees C (5min)).

[0112] When 281 in drawing forms uniform ****, 282 shows respectively the case where gradual **** is formed.

[0113] It turns out that the direction in the case of the result of drawing 28 to this lead metal layer falling toward a pewter layer more gradually than the uniform layer which has a value with fixed concentration shows high reliability.

[0114] The reliability of the semiconductor device using this invention came from these results enough as compared with the conventional method, and a certain thing was checked.

[0115] In addition, it was also checked that especially reliability of the semiconductor device by this invention improves remarkably when a resin seal is performed.

[0116] The barrier metallic material furthermore used for this invention cannot be limited to Cu and nickel, and can use Au, W, Ag, aluminum, Cr, or Ti. Moreover, as for the pewter bump material to form, for example, not only an Pb-Sn alloy but Sb, Bi, In, Ga, germanium, etc. may be mixed, and the effect does not change at all.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The cross-section block diagram showing the fundamental structure of the semiconductor device concerning this invention

[Drawing 2] The partial block diagram showing the fundamental structure of the electronic-circuitry equipment which carried out flip chip mounting of the semiconductor device concerning this invention

[Drawing 3] The outline cross section of the semiconductor device concerning the gestalt of operation of the 1st of the semiconductor device concerning this invention

[Drawing 4] The outline cross section showing the gestalt of operation of the 2nd of the semiconductor device concerning this invention

[Drawing 5] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 6] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 7] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 8] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 9] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 10] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 11] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 12] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 13] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 14] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 15] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 16] Drawing for explaining the manufacturing process of the semiconductor device equipped with the bump electrode concerning the 1st gestalt

[Drawing 17] Drawing showing an example of the configuration of the barrier layer formed in the interior of a bump electrode

[Drawing 18] Drawing showing other examples of the configuration of the barrier layer formed in the interior of a bump electrode

[Drawing 19] Drawing for explaining the process which mounts a semiconductor device in a circuit wiring substrate

[Drawing 20] Drawing for explaining the process which mounts a semiconductor device in a circuit wiring substrate

[Drawing 21] Drawing for explaining the process which mounts a semiconductor device in a circuit wiring substrate

[Drawing 22] Drawing showing other examples of the semiconductor device equipped with the bump electrode concerning this invention

[Drawing 23] The graphical representation showing the reliability of the electronic-circuitry equipment concerning the 1st of this invention, and the 2nd form

[Drawing 24] The graphical representation showing the reliability of the electronic-circuitry equipment concerning the 1st form of this invention by elevated-temperature preservation

[Drawing 25] The graphical representation showing the reliability of the electronic-circuitry equipment concerning the 2nd form of this invention by elevated-temperature preservation

[Drawing 26] The graphical representation showing the relation between each thickness of the 1st connection layer of the two-layer structure, and share intensity

[Drawing 27] The GUFU view showing the relation of the metaled lead concentration and share intensity which are formed as 2nd connection layer

[Drawing 28] The graphical representation showing the evaluation result of the difference in the reliability by composition of a lead content layer

[Drawing 29] Drawing for explaining a Prior art

[Drawing 30] Drawing for explaining a Prior art

[Drawing 31] Copper-tin state diagram

[Drawing 32] Nickel-tin state diagram

[Description of Notations]

1 -- Semiconductor chip
2 -- Barrier metal layer
3 -- Solder bump
4 -- 1st connection layer
5 -- 2nd connection layer
6 -- Passivation film
21 -- Circuit wiring substrate
22 -- Solder resist
23 -- Terminal for connection
24 -- Bump electrode
31 -- Cu3 Sn layer
32 -- Cu6 Sn5 Layer
33 -- High concentration ****
41 -- nickel3 Sn4 Layer
42 -- Barrier metal
51 -- Plating resist
52 -- Copper

53 -- Etching resist
54 -- Collet
55 -- Substrate heating heater
56 -- Closure resin

[Translation done.]

* NOTICES *

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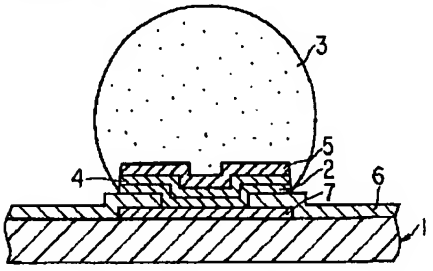
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



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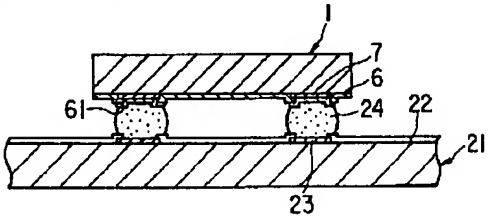

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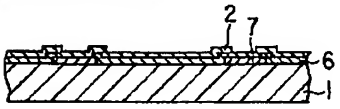

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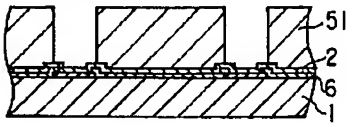

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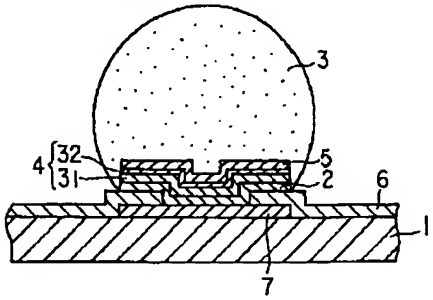

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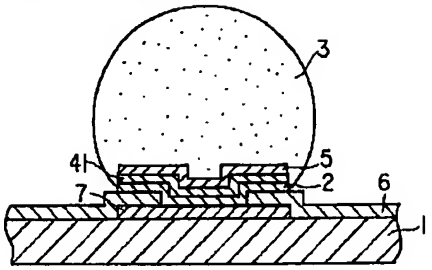

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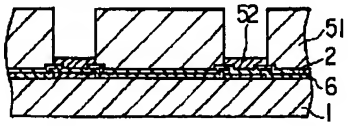

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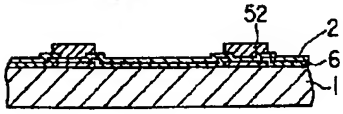

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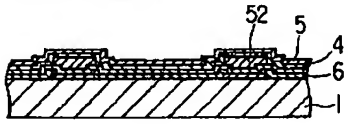

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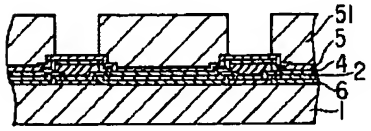

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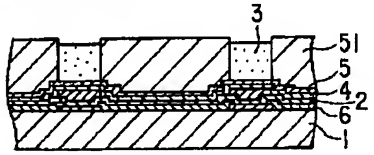

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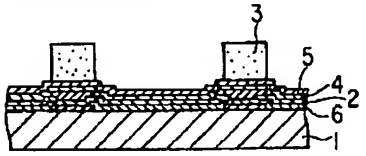

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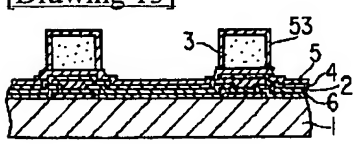

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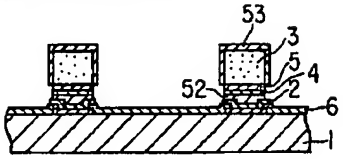

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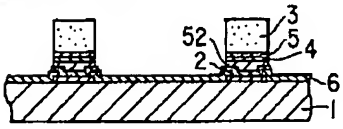

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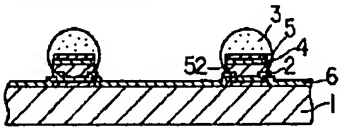

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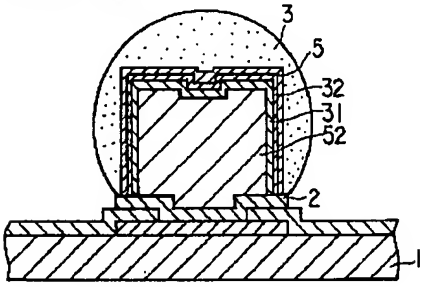

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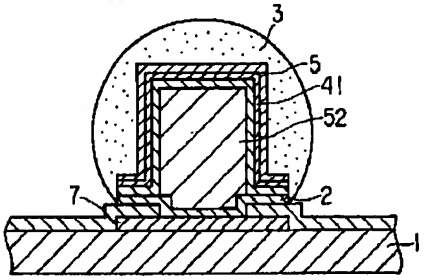

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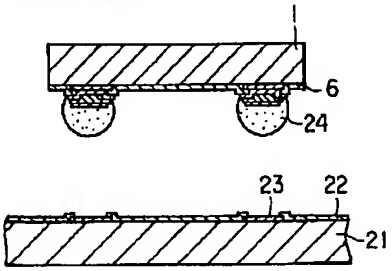

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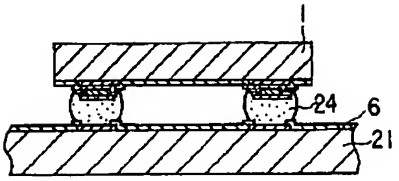

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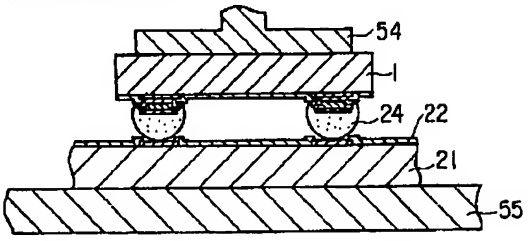

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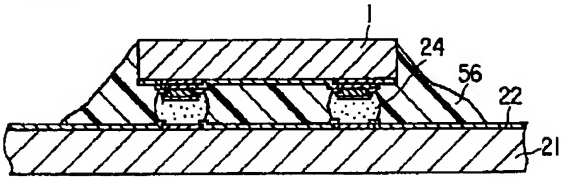

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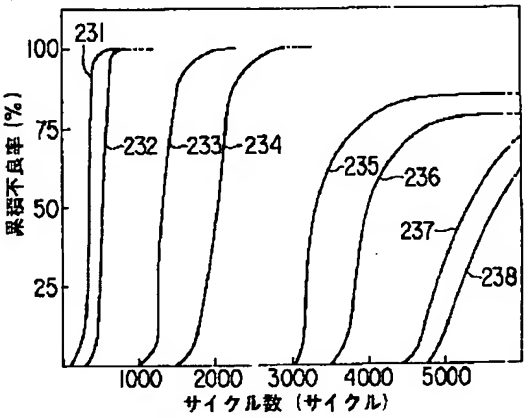

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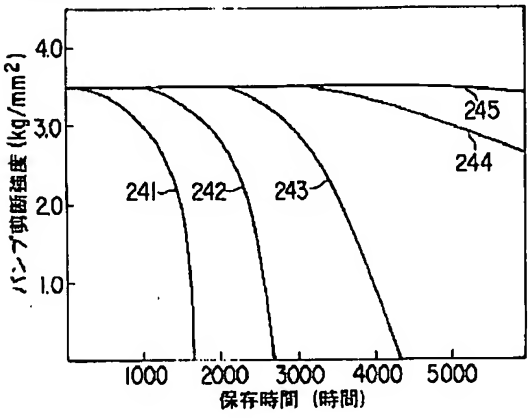

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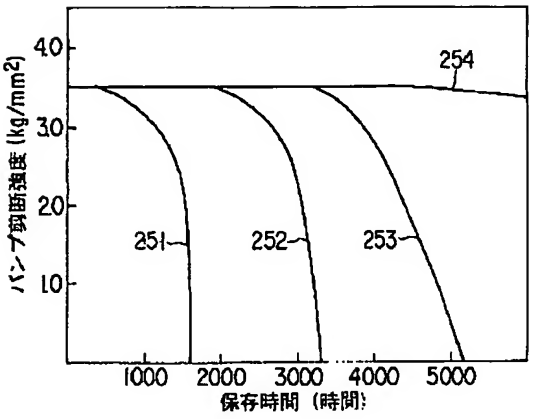

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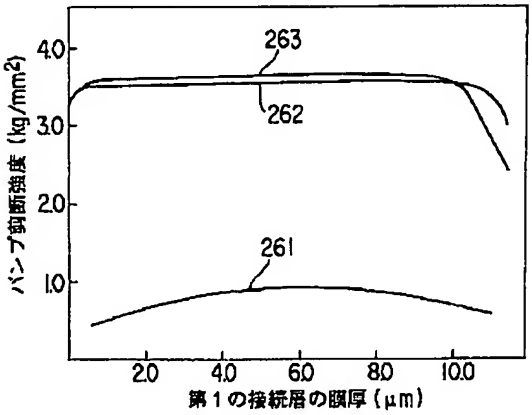

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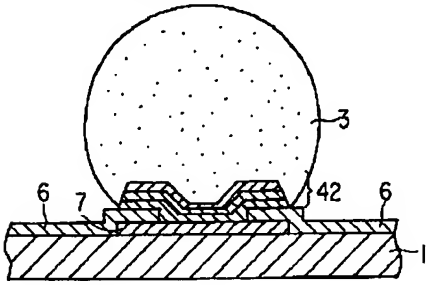

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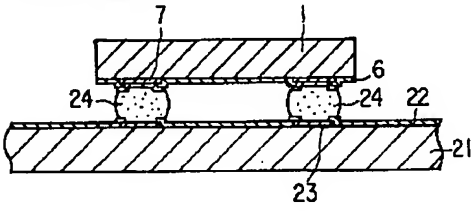

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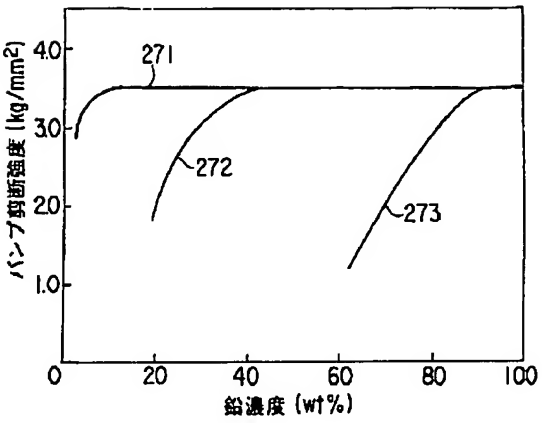

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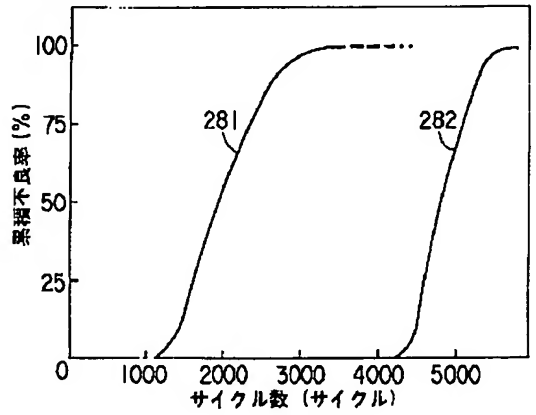

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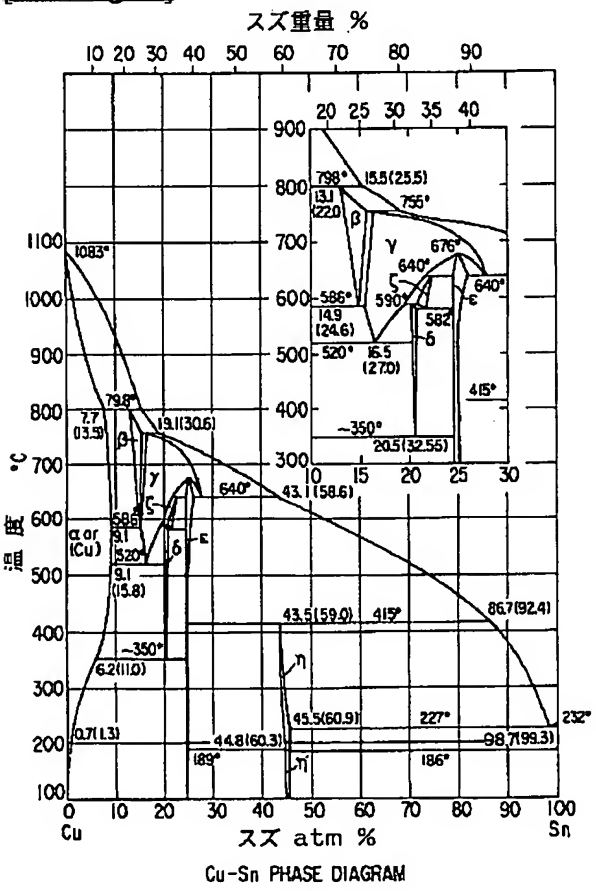

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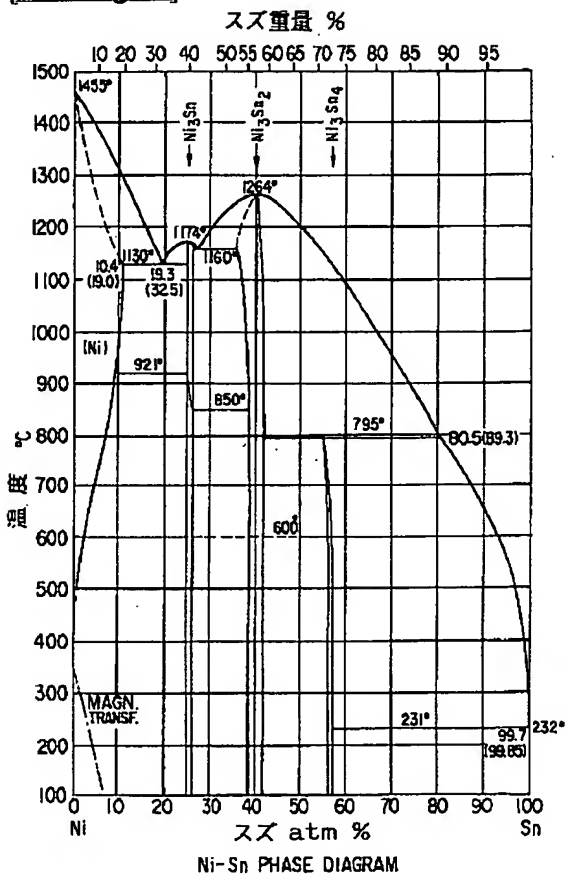

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